Report of the South African Association for the Advancement of Science.

Pretoria, 1915.

REPORT

OF THE

THIRTEENTH ANNUAL MEETING OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE.

PRETORIA,

1915.

JULY 5—10.

CAPE TOWN:
PUBLISHED BY THE ASSOCIATION.

1916.

CONTENTS.

LIST OF PLATES.

OFFICERS AND COUNCIL, 1914-1915.

HONORARY PRESIDENT.

HIS MAJESTY THE KING.

PRESIDENT.

R. T. A. INNES, F.R.A.S., F.R.S.E.

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Sir A. THEILER, K.C.M.G., D.Sc., Director of Veterinary Research, Pretoria.
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H. E. WOOD, M.Sc., F.R.Met.Soc., Union Observatory, Johannesburg.

HON. GENERAL TREASURER.

A. WALSH, P.O. Box 39, Cape Town.

ASSISTANT GENERAL SECRETARY.

H. TUCKER, Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town. P.O. Box 1497. (Telegraphic Address: "Scientific.")

ORDINARY MEMBERS OF COUNCIL.

I. CAPE PROVINCE.

Cape Peninsula.

A. J. ANDERSON, M.A., M.B., D.P.H., M.R.C.S.
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A. STEAD, B.Sc., F.C.S.

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S. EVANS.
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J. A. FOOTE, F.G.S., F.E.I.S.

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J. E. ADAMSON, M.A.
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A. K. HAAGNER, F.Z.S.
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J. L. SOUTTER.

Potchefstroom.

F. G. TYERS, M.A.

III. ORANGE FREE STATE.

Bloemfontein.

Prof. T. M. FORSYTH, M.A., D.Phil.
Dr. W. JOHNSON, L.R.C.P., L.R.C.S.
Prof. G. POTTS, M.Sc., Ph.D.

IV. NATAL.

Pietermaritzburg.

Dr. J. HYSLOP, D.S.O., M.B., C.M.

V. RHODESIA.

Bulawayo.

Rev. S. S. DORNAN, M.A. F.G.S.

VI. MOZAMBIQUE.

S. SERUYA.

TRUSTEES.

Endowment Fund.

J. W. JAGGER, F.S.S., M.L.A.
W. RUNCIMAN, M.L.A.
A. D. R. TUGWELL.

S.A. Medal Fund.

W. E. GURNEY.
Sir T. MUIR, Kt., C.M.G., M.A., LL.D., F.R.S., F.R.S.E.
W. THOMSON, M.A., B.Sc., LL.D., F.R.S.E.

CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As amended at the Thirteenth Annual Meeting at Pretoria, 1915.*]

I.—OBJECTS.

The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), and (c) Temporary Members, elected for a session, hereinafter called "Associates."

(*c*) Members and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*d*) The Council shall have the power, by a two-thirds vote, to remove the name of anyone whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission,* their Annual Subscription.

(*c*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*d*) Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) Every Life Member shall pay, on admission as such, the sum of Ten Pounds.

(*b*) Ordinary Members shall pay, on election, an Annual Subscription of One Pound. Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(*c*) An Ordinary Member may at any time become a Life Member by one payment of Ten Pounds in lieu of future Annual Subscriptions. An Ordinary Member may, after ten years, provided that his subscriptions have been paid regularly without intermission, become a Life Member by one payment of Five Pounds in lieu of future Annual Subscriptions.

(*d*) The Subscription for Associates for a Session shall be Fifteen Shillings.

V.—MEETINGS.

The Association shall meet in Session Annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries and a General Treasurer, together with one Member of Council for every twenty Members of the Association.

(*c*) The President, Vice-Presidents, General Secretaries and General Treasurer shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(*d*) Ordinary Members of Council to represent centres having more than 20 Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(*e*) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next ensuing Session is to be held.

(*f*) In the event of a vacancy occurring in the Council, or among the Officers of the Association, in the intervals between the Annual Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(*g*) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such Meetings as may be necessary during the Annual Session of the Association.

(*h*) The Council shall have the power to pay for the services of Assistant General Secretaries, for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(*i*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Cape Town.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 31st of May.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association, except by resolution of a General Meeting; provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, may, upon the death of such Member, be repaid by the Trustees to the General Account of the Association, if the Council shall so decide.

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* The Reception Committee should make arrangements to provide:—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Four rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) On the request of the majority of the Members of Council of any Centre in which two or more Members of Council reside, the Council shall empower the local Members of Council in that Centre to expend sums not exceeding in the aggregate 10 per centum of the amount of Annual Subscriptions raised in that Centre.

(*g*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology; Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geodesy and Surveying; Geography, Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology; Political Economy; Sanitary Science; Sociology; Statistics, Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of

the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable, in order to give an oppor-

tunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Session before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by Circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

During the interval between two Annual Sessions of the Association, any alterations proposed to be made in the Rules shall be valid if agreed to by two-thirds of the Members of Council. Such alteration of Rules shall not be permanently incorporated in the Constitution until approved by the next Annual Meeting.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A. The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee" on which, as far as possible, every Section of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) Each new Committee shall retain not less than four members who have served on the previous Committee.

(*d*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*e*) Any casual vacancy in the Committee shall be filled by the Council.

II.—Duties.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution reads as follows:—

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancenent of Science.

(2) That the Dies for the Medal be transferred to the Association, to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, 2½ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—Awards.

(*a*) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Fund shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award nay be made by any member of the South African Association for the

Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby, in a subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Rule XIV. of the Association's Constitution, reading:—

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will *ipso facto* forfeit his seat on the Committee.

B. The Goold-Adams Medals.

(*a*) The Medals shall be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects; (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University Matriculation Examination and the University Senior Certificate Examination; and who is not over the prescribed age for Exhibitions at the Matriculation Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

(*e*) The first awards shall be made on the results of the 1910 examinations.

BYE-LAWS

Under which the O.F.S. Philosophical Society was incorporated, from 1st July, 1914, with the South African Association for the Advancement of Science, with the designation of "The Orange Free State Branch" of the Association.

1. The O.F.S. Philosophical Society to be incorporated with the South African Association for the Advancement of Science, this being the only course of procedure open under the existing Constitution.

2. The title of the Society so incorporated to be "The Orange Free State Branch of the South African Association for the Advancement of Science."

3. All members of the South African Association for the Advancement of Science resident in the Orange Free State will, for purposes of these bye-laws, be considered members of the Orange Free State Branch of the Association.

4. The local Committee of the Branch to consist of the Council members of the Association for the Orange Free State, together with such additional members as the Branch may elect to serve on its local Committee.

5. Subscription notices to members of the Branch to be circulated from the Head Office of the Association in Capetown, and subscriptions to be paid to the General Treasurer of the Association at Capetown, 10 per cent. thereof being remitted to the Orange Free State Branch for local expenses. Subscriptions of £1 per annum to entitle to membership of the Association as a whole, as well as of the Orange Free State Branch.

6. All members at present on the books of the Orange Free State Philosophical Society to be entitled to become members of the Association, to receive its Journal, and to enjoy the full privileges of membership, as soon as their subscription of £1 for the financial year 1914-15 shall have been paid.

7. Papers read before the Orange Free State Branch may either (1) be printed by title, abstract, or *in extenso*, in the Journal of the Association for the current year, after reference to the Presidents of the respective Sectional Committees, or (2) be read at the next Annual Session of the Association (provided that they have not been previously published in abstract or *in extenso*), and thereafter printed in the Association's Journal, subject to the ordinary conditions.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. CAPE TOWN, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.ME. Sir Charles Metcalfe, Bart, M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R S.E Gardner F. Williams, M.A.	J. D. F. Gilchrist, **M.A.**, D.Sc., **Ph.D.**, **F.L.S.**
Sir CHARLES METCALFE, Bart., M.I.C.E. JOHANNESBURG, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. JOHANNESBURG, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. KIMBERLEY, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. DURBAN, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer. I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R S.E. Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.

H.E. the Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. — GRAHAMSTOWN, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. — BLOEMFONTEIN, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D. F.R.S., F.R.S.E. — CAPE TOWN, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.
Professor PAUL DANIEL HAHN, M.A., Ph.D. — BULAWAYO, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C. W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G.	G. N. Bromehead.
ARNOLD THEILER, C.M.G., D.Sc. — PORT ELIZABETH, July 1, 1912.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. J. Moir, M.A., D.Sc., F.C.S. A. J. C. Molyneux, F.G.S., F.R.G.S. W. Arnott	E. G. Bryant, B.A., B.Sc.
ALEXANDER W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E. — LOURENCO MARQUES, July 7, 1913.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. R. T. A. Innes, F.R.A.S., F.R.S.E. A. J. C. Molyneux, F.G.S., F.R.G.S. J. H. von Hafe	H. E. Wood, M.Sc., F.R.Met.S.
Professor RUDOLF MARLOTH, M.A., Ph.D. — KIMBERLEY, July 6, 1914.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. S. Evans W. Johnson, L.R.C.P., L.R.C.S. A. F. Williams B.Sc.	A. F. Williams, B.Sc. F. Harrison.
ROBERT T. A. INNES, F.R.A.S., F.R.S.E. — PRETORIA, July 5, 1915.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. G. W. Herdman, M.A., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc. A. H. Watkins, M.D., M.R.C.S., M.L.A.	E. Hope Jones.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ..	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ..	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Reid, G. S. Bishop.
1908. Grahamstown	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND GEOGRAPHY.		
1909. Bloemfontein	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town ‡	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo ..	Rev. E. Goetz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
1912. Port Elizabeth	H. J. Holder, M.I.E.E.	A. H. Reid.
1913. Lourenço Marques	J. H. von Hafe.	Prof. J. Orr, J. Vaz Gomes.
1914. Kimberley ..	Prof. A. Ogg, M.A., B.Sc., Ph.D.	Prof. A. Brown, A. E. H. Dinham-Peren.
1915. Pretoria ..	F. E. Kanthack, M.I.C.E., M.I.M.E.	Prof. A. Brown, J. L. Soutter.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ..	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley ..	Thos. Quentrall, M.I.Mech.E., F.G.S.	C. E. Addams, H. Simpson.
CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.		
1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B, in 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.	Presidents.	Secretaries.

CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.

1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.

CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

1910. Cape Town ..	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911. Bulawayo ..	A. J. C. Molyneux, F.G.S., F.R.G.S.	J. G. Rose, G. N. Blackshaw.
1912. Port Elizabeth	Prof. B. de St. J. van der Riet, M.A., Ph.D.	J. G. Rose, J. E. Devlin.
1913. Lourenço Marques	Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.	Prof. G. H. Stanley, Capt. A. Graça.
1914. Kimberley ..	Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.	J. G. Rose, J. Parry.
1915. Pretoria ..	H. Kynaston, M.A., F.G.S.	Dr. H. C. J. Tietz, Prof. D. F. du Toit Malherbe.

SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING, AND SANITARY SCIENCE.

1903. Cape Town ..	Sir Chas. Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904. Johannesburg *	Lieut.-Colonel Sir Percy Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906. Kimberley ..	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W. Greatbatch, W. Newdigate.

BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.

1907. Natal	Lieut.-Colonel H. Watkins Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908. Grahamstown	Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910. Cape Town †	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
1911. Bulawayo ..	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
1912. Port Elizabeth	F. W. FitzSimons, F.Z.S., F.R.M.S.	W. T. Saxton, I. L. Drège.
1913. Lourenço Marques	A. L. M. Bonn, C.E.	F. Flowers, Lieut. J. B. Botelho.
1914. Kimberley ..	Prof. G. Potts, M.Sc., Ph.D.	C. W. Mally, W. J. Calder.
1915. Pretoria ..	C. P. Lounsbury, B.Sc., F.E.S.	C. W. Mally, A. K. Haagner.

* Forestry added in 1904.
† Sanitary Science added in 1910.

Date and Place.	Presidents.	Secretaries.

SECTION D.—ARCHAEOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1903. Cape Town ..	Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ..	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.

EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY, ARCHAEOLOGY, ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.

1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.

EDUCATION, PHILOLOGY, PSYCHOLOGY, HISTORY AND ARCHAEOLOGY.

1908. Grahamstown	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.

ECONOMICS AND STATISTICS, SOCIOLOGY, ANTHROPOLOGY AND ETHNOLOGY.

1908. Grahamstown	W. Hammond Tooke.	Prof. A. S. Kidd.

ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1909. Bloemfontein	Hugh Gunn, M.A.	G. C. Grant, Rev. W. A. Norton.
1910. Cape Town ..	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911. Bulawayo ..	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.
1912. Port Elizabeth	W. A. Way, M.A.	G. B. Kipps, E. G. Bryant.
1913. Lourenço Marques	J. A. Foote, F.G.S.	H. Pim, J. Elvas.
1914. Kimberley ..	Prof. W. Ritchie, M.A.	Prof. R. D. Nauta, A. H. J. Bourne.
1915. Pretoria ..	J. E. Adamson, M.A.	Prof. R. D. Nauta, R. G. L. Austin.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ..	Prof. W. S. Logeman, B.A., L.H.C.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion — Present and Future.
1906. Kimberley ..	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ..	R. T. A. Innes, F.R.A.S., F.R.S.E.	Some Recent Problems in Astronomy.
Durban	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A Theiler, C.M.G.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1910. Cape Town ..	Prof. H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo ..	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform — Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.
1912. Port Elizabeth	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	Imperial Astronomy.
	Prof. E. J. Goddard, B.A., D.Sc.	Antarctica.
1913. Lourenço Marques	S. Seruya.	The history of Portuguese conquest and discovery.
1914. Kimberley ..	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	The Kimberley Mines, their discovery, and their relation to other volcanic vents in South Africa.
1915. Pretoria ..	E. T. Mellor, D.Sc., F.G.S., M.I.M.M.	The gold bearing conglomerates of the Witwatersrand.
	C. W. Mally, M.Sc., F.E.S., F.L.S.	The House fly under South African conditions.

GENERAL MEETINGS AT PRETORIA.

On *Monday, July* 5, at 3 p.m., the Association was officially welcomed by His Worship the Mayor of Pretoria (Mr. A. Johnston, J.P.) in the General Assembly Hall, Transvaal University College.

On *Tuesday, July* 6, at 2 p.m., Members of the Association were received by Sir Arnold Theiler, K.C.M.G., D.Sc., Director of Veterinary Research, at the Government Bacteriological Laboratory, Onderstpoort.

At 8.15 p.m. the Association attended a reception by the Mayor and Mayoress of Pretoria, in the Town Hall, when Mr. R. T. A. Innes, F.R.A.S., F.R.S.E., took the chair as President, and delivered an address, for which see page 1. A vote of thanks was accorded to the President by acclamation, on the motion of the Rev. Dr. Flint.

The President then presented the South Africa Medal and grant to Dr. C. F. Juritz, for conveyance to Mr. C. P. Lounsbury, B.Sc., F.E.S., who had left for Australia. For the proceedings, see page xxxii.

On *Wednesday, July* 7, at 3.30 p.m., Members of the Association attended a Reception by the Mayor, Mayoress, and Town Council of Pretoria in the Zoological Gardens.

At 8.15 p.m., in the Town Hall, Dr. E. T. Mellor, D.Sc., F.G.S., M.I.M.M., delivered a discourse on "The Gold-bearing conglomerates of the Witwatersrand," Mr. F. E. Kanthack, Director of Irrigation, presiding.

On *Thursday, July* 8, at 10.30 a.m., the Thirteenth Annual General Meeting was held in the General Assembly Hall, Transvaal University College, for minutes of which see page xx.

At 1.48 p.m. Members proceeded on excursions to the Waterworks at Fountains Valley, the Union Buildings and Plant Pathologist's Station, the Governor-General's residence and Eastern Sports Ground, and the Transvaal Museum.

At 8.15 p.m. Members attended a Reception given by the Reception Committee, assisted by the Biological Society, in the Town Hall.

On *Friday, July* 9, at 2.30 p.m., excursions took place to the Municipal Abattoirs, the Sewage Outfall Works, the late President Kruger's residence, statue, and grave.

At 4.30 p.m. Members visited the Municipal Fire Station, where a special demonstration by the Fire Brigade was given.

On *Saturday, July* 10, at 8.15 a.m., Members proceeded to Johannesburg and visited the Crown Mines, Ltd., after which they were entertained at luncheon by the Chairman and Directors. They subsequently proceeded on an excursion round the suburbs of Johannesburg by special tramcar.

At 7.45 Members left Pretoria for Potchefstroom, on a visit to the Government School of Agriculture and Experiment Farm.

On *Monday, July* 12, in the Town Hall, Pretoria, Mr. C. W. Mally, M.Sc., F.E.S., F.L.S., delivered a discourse on "The House Fly under South African conditions," Dr. J. J. Boyd, Medical Officer of Health, presiding.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, PRETORIA, 1915.

LOCAL COMMITTEE.

Chairman, Sir A. Theiler, K.C.M.G., D.Sc.; J. E. Adamson, M.A., G. W. Herdman, M.A., M.I.C.E., A. K. Haagner, F.Z.S., F. E. Kanthack, M.I.C.E., M.I.M.E., D. Kehoe, M.R.C.V.S., Prof. W. A. Macfadyen, M.A., LL.D., Prof. D. F. du Toit Malherbe, M.A., Ph.D., J. L. Soutter. *Local Secretary,* E. Hope Jones.

RECEPTION COMMITTEE.

Chairman, His Worship the Mayor of Pretoria (Councillor Andrew Johnston, J.P.); the Deputy Mayor (Councillor C.M. de Vries); Councillors R. A. Kerr, J. J. Leggett, M. G. Nicholson, W. Nivison, M. Simon and Sir J. van Boeschoten, Kt.; Rev. H. S. Bosman, B.A., Dr. J. J. Boyd, Rev. A. Burnett, Dr. H. Davies, The Very Rev. the Dean of Pretoria, Dr. F. V. Engelenburg, J. H. L. Findlay, F. W. Jameson, H. C. Jorissen, J. Barclay Lloyd, C. Maggs, H. L. Malherbe, E. Rooth, H. Rose-Innes, J. Rissik, Dr. H. P. Veale, M.B., C.B., T. N. de Villiers, Hon. Sir J. W. Wessels, B.A., LL.B., T. C. Wolley-Dod; J. H. Venning, *Hon. Secretary.*

SECTIONAL COMMITTEES.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE, AND IRRIGATION.

President, F. E. Kanthack, M.I.C.E., M.I.M.E.; *Vice-Presidents,* G. W. Herdman, M.A., M.I.C.E., and Prof. J. Orr, B.Sc., M.I.C.E.; *Members,* Prof. R. H. Charters, M.I.C.E., Prof. P. G. Gundry, B.Sc., Ph.D., A.R.C.S., Prof. R. A. Lehfeldt, B.A., D.Sc., Prof. A. Ogg, M.A., B.Sc., Ph.D., A. H. Reid, F.R.I.B.A., F.R.San.I., A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E., and H. E. Wood, M.Sc., F.R.Met.S.; *Hon. Secretaries,* Prof. A. Brown, M.A., B.Sc., F.R.S.E. (*Recorder*), and J. L. Soutter.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President, H. Kynaston, M.A., F.G.S.; *Vice-Presidents,* E. T. Mellor, D.Sc., F.G.S., and Prof. J. A. Wilkinson, M.A., F.C.S.; *Members,* C. F. Juritz, M.A., D.Sc., F.I.C., Miss C. J. Maury, Ph.D., Prof. S. J. Shand, D.Sc., Ph.D., F.G.S., Prof.

G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C,, and Prof. R. B. Young, M.A., D.Sc., F.G.S., F.R.S.E.; *Hon. Secretaries,* H. C. J. Tietz, M.A., Ph.D. (*Recorder*), and Prof. D. F. du Toit Malherbe, M.A., Ph.D.

Section C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE, AND SANITARY SCIENCE.

President, C. P. Lounsbury, B.Sc., F.E.S.; *Vice-Presidents,* I. B. Pole-Evans, M.A., B.Sc., F.L.S., and Sir A. Theiler, K.C.M.G., D.Sc.; *Members,* F. A. Arnold, M.B., D.P.H., L.S.A., J. Burtt-Davy, F.L.S,, FR.G.S., A. Holm, D. Kehoe, M.R.C.V.S., Prof. R. Marloth, M.A., Ph.D., Prof. G. Potts, M.Sc., Ph.D., Prof. H. A. Wager, A.R.C.S.; *Hon, Secretaries,* C. W. Mally, M.Sc., F.E.S., F.L.S. (*Recorder*), and A. K. Haagner, F.Z.S.

Section D.—ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY, AND STATISTICS.

President, J. E. Adamson, M.A.; *Vice-Presidents,* W. E. C. Clarke, M.A., and Prof. W. A. Macfayden, M.A., LL.D.; *Members,* A. H. J. Bourne, M.A., Dr. F. V. Engelenburg, J. A. Foote, F.G.S., F.E.I.S., Prof. T. M. Forsyth, M.A., D.Phil., G. T. Morice, B.A., K.C., H. Pim, B.A., F.C.A., Prof. W. Ritchie, M.A., Miss Bertha Stoneman, D.Sc., and Miss M. Wilman; *Hon. Secretaries,* Prof. R. D. Nauta (*Recorder*), and R. G. L. Austin.

PROCEEDINGS OF THE THIRTEENTH ANNUAL GENERAL MEETING OF MEMBERS.

(Held in the Transvaal University College, Pretoria, on Thursday, July 8, 1915.)

PRESENT: R. T. A. Innes, F.R.A.S., F.R.S.E. (President), in the chair; Messrs. J. E. Adamson, A. Bottomley, C. K. Brain, Dr. J. Brown, H. J. Burroughs, Prof. R. H. Charters, E. H. Clephan, Dr. J. P. Dalton, G. de Kock, Dr. E. M. Doidge, Miss A. M. H. du Boulay, I. B. Pole Evans, Rev. J. FitzHenry, Rev. Dr. W. Flint, Mrs. E. Forsyth, Prof. T. M. Forsyth, H. H. Green, D. Gunn, Miss J. Henderson, G. W. Herdman, Mrs. A. E. Innes, E. Hope Jones, F. E. Kanthack, J. A. Kendall, H. C. Kenway, Prof. W. A. Macfadyen, Prof. D. F. du T. Malherbe, C. W. Mally, Adv. G. T. Morice, D. T. Mitchell, Rev. E. W. H. Musselwhite, Rev. W. A. Norton, Prof. J. Orr, Miss G. E. Pollard, A. Roberts, E. M. Robinson, Dr. Jane B. H. Ruthven, Prof. E. H. L. Schwarz, Prof. S. J. Shand, E. Holmes Smith, Mrs. J. F. Solly, A. J. Spanner, Miss S. Stafford, J. D. Stevens, Dr. Bertha Stoneman, C. J. Swierstra, Miss E. L. Teasdale, Sir A. Theiler, P. van der Byl, Miss J. M. van Riet, Prof. H. A. Wager, J. Walker, Prof. J. A. Wilkinson, Miss M. Wilman, Dr. C. F. Juritz and H. E. Wood (General Secretaries), A. Walsh (General Treasurer), and H. Tucker (Asst. General Secretary).

MINUTES.—The Minutes of the Twelfth Annual General Meeting, held at Kimberley on 9th July, 1914, and printed on pp. xix to xxiii of the Report of the Kimberley Session, were confirmed.

ANNUAL REPORT OF COUNCIL.—The Annual Report of the Council for 1914-15, having been suspended in the Entrance Hall since 6th July, was taken as read, and adopted, on the motion of Rev. Dr. Flint (see p. xxv).

REPORT OF GENERAL TREASURER AND STATEMENT OF ACCOUNTS FOR 1914-15.—The General Treasurer's Report and the audited Financial Statements for 1914-15, having been suspended in the Entrance Hall since 6th July, were taken as read, and adopted, on the motion of Prof. Malherbe (see p. xxix).

ELECTION OF OFFICERS FOR 1915-16.—The following officers were elected for 1915-16:—

PRESIDENT, Prof. L. Crawford, M.A., D.Sc., F.R.S.E.; VICE-PRESIDENTS, Rev. W. Flint, D.D.; Prof. J. Orr, B.Sc., M.I.C.E.; Sir A. Theiler, K.C.M.G., D.Sc.; Prof. B. de St. J. van der Riet, M.A., Ph.D.; GENERAL SECRETARIES, Dr. C. F. Juritz, M.A., F.I.C., and Mr. H. E. Wood, M.Sc., F.R.Met.S.; GENERAL TREASURER, Mr. A. Walsh. (The retiring President, Mr. R. T. A. Innes, F.R.A.S., F.R.S.E., is a Member of Council, *ex officio*, for the year.)

ELECTION OF COUNCIL MEMBERS FOR 1915-16.—The following were elected Members of Council for 1915-16:—

I. CAPE PROVINCE.—(1) *Cape Peninsula*: Dr. A. J. Anderson, M.A., M.B., D.P.H., M.R.C.S., Prof. A. Brown, M.A., B.Sc., Dr. J. Lunt, F.I.C., Messrs. R. W. Menmuir, A.M.I.C.E., and A. H. Reid, F.R.I.B.A., F.R.San.I. (2) *Grahamstown*: Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. (3) *Kimberley*: Miss M. Wilman. (4) *King William's Town*: Dr. A. W. Roberts, F.R.A.S., F.R.S.E. (5) *Middelburg*: Mr. R. W. Thornton. (6) *Port Elizabeth*: Mr. W. A. Way, M.A. (7) *Stellenbosch*: Prof. E. Goddard, B.A., D.Sc.

II. TRANSVAAL.—(1) *Johannesburg*: Messrs. J. Burtt-Davy, F.L.S., F.R.G.S., W. A. Caldecott, B.A., D.Sc., F.C.S., P. Cazalet and W. Ingham, M.I.C.E., M.I.M.E., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., Mr. J. A. Vaughan and Prof. J. A. Wilkinson, M.A., F.C.S. (2) *Pretoria*: Messrs. I. B. Pole Evans, M.A., B.Sc., F.L.S., F. E. Kanthack, M.I.C.E., M.I.M.E., D. Kehoe, M.R.C.V.S., and Prof. D. F. du T. Malherbe, M.A., Ph.D. (3) *Potchefstroom*: Mr. E. Holmes Smith, B.Sc.

III. ORANGE FREE STATE (including Basutoland).—(1) *Bloemfontein*: Prof. T. M. Forsyth, M.A., D.Phil. and Dr. W. A. Johnson, L.R.C.P., L.R.C.S.

IV. NATAL.—(1) *Pietermaritzburg*: Prof. W. N. Roseveare, M.A.

V. RHODESIA.—(1) *Bulawayo*: Rev. S. S. Dornan, M.A., F.G.S.

VI. MOZAMBIQUE.—(1) *Lourenço Marques*: S. Seruya.

ALTERATIONS IN CONSTITUTION.—(1) *S.A. Medal Committee: Term of Office.* The motion of Prof. Schwarz: "That Sub-Section A I of the Rules for the Award of Medals be amended by the insertion of the following new clause (*c*) the existing clauses (*c*) and (*d*) being re-lettered (*d*) and (*e*):—'One third of the members of this Committee shall retire annually by rotation, but shall be eligible for re-election,'" was discussed; and an amendment by Mr. Kanthack was carried, that the new clause (*c*) should read as follows: "Each new Medal Committee shall retain not less than four members who have served on the previous Committee"; and that the decision as to the members to be so retained should be left to the Council."

(2) *Allocation of Life Membership Subscriptions.*—The motions of (*a*) Dr. Potts:—"That the following clause be added to Section IX (*b*) of the Constitution, *viz.*, 'Provided that, when Life Membership subscriptions of £5 are received from Members under Section IV (*c*), £1 10s. thereof shall be credited to the year's current income'"; and (*b*) Mr. Walsh:—"To add to Section IX (*b*) the following clause, 'provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, shall, upon

the death of such Member, be repaid by the Trustees to the General Account of the Association,' " were discussed; and it was resolved, on the motion of Rev. Dr. Flint, to adopt the motion of Mr. Walsh, subject to the following amendment, *viz.*, that the words "may, if the Council shall so decide," be substituted for the word "shall."

Admission of Public to Sectional Meetings.—The motion of Dr. Potts, carried at the last Annual General Meeting, that the attention of the incoming Council be directed to the desirability of admitting the public to Sectional Meetings, was re-submitted by the Council for discussion; the Council being of opinion that, in view of the importance of the issues involved, the matter should be reserved for the decision of the Annual General Meeting. The following is the memorandum obtained by the Council from Dr. Potts in support of his proposal:—

"The attendance is often very small, which is disheartening to everyone, especially the authors of papers, if present. At Section C, in 1914, the average attendance was about three—the President, Secretary, and one other Member, who read the paper for the absent author.

"If the public were admitted, it would probably increase the attendance, and might result in the acquisition of new members for the Association. It would also be a further return for the hospitality of the town."

On this the Council added the following comment:—"The Council inclines to the view that such a course would deprive local residents of their chief inducement to pay 15s. and become Associate Members for the Session, and would thus reduce the funds available for use by the Local Committee to defray expenses: the subscriptions received from Associates being an asset of the Local Committee."

On the motion of the Chairman, it was resolved to refer the matter back to the incoming Council for disposal, together with the subjoined further proposals for the conduct of future Sessions, which were submitted by Prof. Shand:—

(*a*) That in future years a list of the papers offered to the Association be issued to Members some time before the commencement of the Session.

(*b*) That with this list be issued balloting cards, and that Members be asked to return these cards to the Secretary, having indicated upon them, by number, *those papers which they particularly desire to hear.*

(*c*) That the Council do then scrutinize the balloting cards, and that those papers which shall have received the greatest numbers of votes (the minimum to be at the discretion of the Council) be appointed to be read at *General Meetings of all Sections;* and that the remaining papers be allocated among the various Sections separately.

(*d*) That the Council arrange the agenda of the next and future meetings of the Association, so that these General Meetings of all Sections (including the Presidential Address of each Section) shall have precedence over the Sectional Meetings.

ENEMY ALIENS ON MEMBERSHIP ROLL.—Mr. H. J. Burroughs moved:—"That the names of all enemy aliens be struck off the list of members of the Association, and that steps be taken to amend the bye-laws so that they provide for the future that, in the event of war existing between the British Empire and other countries, citizens or subjects of which are honorary members or members of this Association, such honorary members or members shall, *ipso facto*, cease their membership."

This having been seconded by Mr. Holmes Smith, a discussion ensued, which indicated that the general feeling of the meeting was emphatically opposed to the motion, Science being regarded as international in character, and the idea of investigating the nationality of any supporter of the Association being deplored as undignified and out of place. It was further pointed out that the very few enemy subjects who were members of the Association would, if the war were prolonged, be eliminated in the ordinary course by the fact that they could not pay their subscriptions.

The mover, in declining an appeal to withdraw his motion, mentioned that, in the Iron and Steel Institute, a similar motion had been adopted.

A vote was taken and the motion was rejected, only three votes being recorded in its favour.

VOTES OF THANKS.—It was proposed by Prof. Orr, and carried by acclamation, that the hearty thanks of the Association be accorded to the following:—

(1) To His Worship the Mayor and the City Councillors for the cordial welcome extended to the Association; and for all the facilities afforded to the members for visiting local institutions and places of interest; and also for granting the free use of the Town Hall for the various functions.

(2) To His Worship the Mayor and the Mayoress for the most enjoyable Receptions given at the Town Hall and (in conjunction with the Councillors) at the Zoological Gardens.

(3) To the Local and Reception Committees, and in particular to their respective Hon. Secretaries, Messrs. E. Hope-Jones and J. H. Venning, for the excellent arrangements made for the accommodation of members for the purposes of the Session, and for their general comfort and convenience; and also for all the willing assistance rendered during the Session.

(4) To the Reception Committee and the Biological Society, for the kind invitation given to members to a Reception at the Town Hall.

(5) To the Council of the Transvaal University College, for the use of the College Buildings during the Session, and of the Students' Hostel as a place of residence for male members.

(6) To the Committee of the Girls' High School, and in particular to Miss Headridge, for the accommodation provided at the North Lodge for lady members.

(7) To Sir Arnold Theiler and the Union Department of Agriculture, for the most interesting excursion provided for the members to the Bacteriological Laboratory at Onderstepoort.

(8) To Mr. I. B. Pole Evans, for granting facilities for visiting the Plant Pathology Station; and to the Committee of the Transvaal Museum for similar facilities afforded for visiting that Institution.

(9) To Mr. A. K. Haagner, Director of the Zoological Gardens, for all the courtesy shown and kindly assistance given to members in connection with their visits to the Zoological Gardens.

(10) To the Works Department of the Municipality, and in particular to Mr. Wolley-Dod, Electrical Engineer and Transport Superintendent, for facilities afforded over their tramway system, and the provision of special busses.

(11) To the Chairman and Directors of the Crown Mines, Ltd., Johannesburg, for their kind invitation to members to visit the mines on the last day of the Session, and for the hospitality offered in connection therewith.

(12) To the Principal of the Government School of Agriculture at Potchefstroom, for the kind invitation given to members to visit that Institution, and for the hospitality offered in connection therewith.

(13) To the Pretoria Club, the Country Club, the Pretoria Golf Club, and the Civil Service Club, for extending the privileges of Honorary Membership to the members during the Session.

(14) To the S.A. Railways, and in particular to the Divisional Superintendent, Pretoria, for railway facilities provided during the Session.

(15) To Mr. Hafner, Registrar of the Transvaal University College, for much willing assistance rendered during the Session.

(16) To the local and Johannesburg Press, for their kindly references to the visit of the Association, and for giving publicity to the proceedings of the Session.

On the motion of Rev. Dr. Flint, further cordial votes of thanks were accorded to the President, Mr. R. T. A. Innes, the General Secretaries, Dr. C. F. Juritz and Mr. H. E. Wood, and the Asst. General Secretary, Mr. H. Tucker, for all that they had done to promote the success of the Session.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1915.

1. Obituary: Since the last Annual Session of the Association your Council has had to deplore the decease of Sir George Farrar, Bart., and Captain F. H. Harrison, local Secretary at Kimberley during last Session, both of whom met their death in connection with the military operations in German South-West Africa.

2. Sir Thomas Muir: Your Council desires to record its appreciation of the honour of Knighthood, which His Majesty the King has been pleased to bestow on Dr. Thomas Muir, F.R.S., Superintendent of Education in the Cape Province, who was President of this Association during its meeting at Cape Town in 1910.

3. Membership: The disturbed state of South Africa, due to the war and the late rebellion, is no doubt responsible in part for the fact that the number of new members elected during the last twelve months was only 25—a figure far below the average. The deaths of four members, including the two whose names have been mentioned above, have been reported during the year, and 53 have resigned, or were removed from the roll of membership on account of non-payment of subscriptions for two years or longer, or because their address is unknown. The Association, therefore, numbered 32 members fewer on the 1st July, 1915, than on the corresponding date of last year.

The following table compares the number of members on the Association books on the two dates, and their distribution:—

	1914.	1915.
Cape Province	218	212
Transvaal	232	216
Orange Free State	35	35
Natal	24	23
Rhodesia	24	20
Basutoland	3	3
Mozambique	24	19
Swaziland	1	1
German South-West Africa	3	2
Abroad	14	15
Unknown	1	1
Total	579	547

4. Life Members: Consequent upon the amendment of Section IV (c) of the Constitution, adopted at the Annual General Meeting at Kimberley on the 9th July, 1914, whereby ordinary members of ten years' standing, who had paid their subscriptions regularly without intermission, acquired the

privilege of being enrolled as Life Members on payment of £5, there has been a considerable increase of Life Members, of whom there are now 61, as compared with 32 a year ago.

5. Report of Lourenco Marques Meeting, 1913: The tenth Annual volume, comprising the proceedings of the Association at Lourenço Marques was completed, as anticipated in last Annual Report, in fourteen issues. The volume consists of 533 pages, and is, therefore, practically identical in size with the Bloemfontein volume of 1909. The tenth volume contains 34 papers printed in full, one in abstract, and three by title only.

6. Report of the Kimberley Meeting, 1914: This volume is being completed in ten monthly issues, the Council's desire being to commence publication of the Pretoria volume within one month of the present Session. In consequence of this decision the average monthly issues of the Kimberley proceedings have been rather more bulky than usual. The volume will be completed with the July issue, and will probably consist of about 484 pages. It will contain 39 papers printed in full, two printed in abstract, and four by title.

7. South Africa Medal and Grant, 1915: On the recommendation of the South Africa Medal Committee, consisting of Prof. L. Crawford, M.A., D.Sc., F.R.S.E. (Chairman), J. A. Foote, F.G.S., F.E.I.S., Dr. C. F. Juritz, M.A., F.I.C., Prof. J. Orr, B.Sc., M.I.C.E., Prof. G. Potts, M.Sc., Ph.D., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., Sir A. Theiler, K.C.M.G., D.Sc., Prof. R. A. Lehfeldt, B.A., D.Sc., H. B. Maufe, B.A., F.G.S., Prof. A. Ogg, M.A., B.Sc., Ph.D., and Prof. E. Warren, D.Sc., the eighth award of the South Africa Medal, together with a grant of £50 has been made to Mr. Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Department of Agriculture, Pretoria.

8. Goold-Adams Medals, 1915: The fifth series of annual awards of the medal presented by H.E. Sir Hamilton Goold-Adams, at present Governor of Queensland, in connection with the Matriculation and Senior Certificate Examinations of the University of the Cape of Good Hope, have been made upon the results of the 1914 examinations. The following are the names of the recipients:—

Mathematics: Vincent A. Boulle, Marist Brothers' College, Uitenhage.

Physics: Evert J. Grobbelaar, High School, French Hoek

Chemistry: Vincent A. Boulle, Marist Brothers' College, Uitenhage.

Physical Science: Noel P. Sellick, Grey Institute, Port Elizabeth.

Botany: Margaret Findlay, Girls' High School, Wynberg.

9. BRITISH ASSOCIATION DELEGATES: A large number of members of the British Association for the Advancement of Science, on their way to attend the Australian Meeting, touched at Cape Town in the steamers *Ascanius* and *Euripides* during July, 1914. In conjunction with the Royal Society of South Africa, your Council did all that was possible, during the short time of the visitors' stay in Cape Town, to entertain them suitably. A cordial message of thanks and appreciation was subsequently received by wireless telegraph from Professor H. B. Dixon, on behalf of the British Association members.

10. LEGISLATION REGARDING METEORITES: In your Council's last Annual Report it was announced that the General Secretary of the Association had been commissioned to lay before the British and Australian Associations for the Advancement of Science, during his visit to Australia last year, the desirability of united action with a view to legislation relative to the preservation of meteorites in the interests of science. In due course Dr. Juritz secured the adoption of the following resolution by the Committees of Sections A and C, of the British Association, and subsequently by the Association's General Committee:*

> "That in view of the fact that meteorites which convey information of world-wide importance, are sometimes disposed of privately, in such a way as to deprive the public of this information, the Council be requested to take such steps as may initiate international legislation on the matter."

On return to England the resolution transmitted by the General Committee had been accepted by the Council, and transmitted to the International Association of Academies.

11. PRESENTATION BY SIR THOMAS MUIR: Your Council had the gratification recently of accepting from Sir Thomas Muir, Past President of the Association, the generous and valuable gift of a complete set of volumes of *Nature*, beginning with its first publication in 1870. The Council's sincere acknowledgments were expressed to Sir Thomas Muir for so valuable an addition to the Association's Library.

12. ENDOWMENT FUND: Owing to the death of Mr. H. M. Arderne and the resignation of the office of Trustee by Prof. J. C. Beattie, to both of whom the Association is deeply indebted for their services, it devolved upon the Council to appoint two new Trustees of the Endowment Fund. It is with much pleasure that your Council is able to report that Mr. J. W. Jagger, F.S.S., M.L.A., and Mr. W. Runciman, M.L.A., have consented to accept office as Trustees along with Mr. A. D. R. Tugwell, who still continues in office.

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* Vide *Brit. Ass. Report*, Australia, (1914) p. lxiv.

13. Research Grants: Your Council has nominated Rev. Dr. W. Flint, Mr. A. H. Reid, Prof. R. Marloth, and Dr. J. Lunt, to represent the Association on the General Committee for Research Grants administered by the Council of the Royal Society of South Africa.

14. Proposed New Sub-Section: Your Council has considered a resolution adopted by the Committee of Section D at the Kimberley Session, to the effect that, in view of the increasing interest shown in native subjects, a new sub-section, whose function it would be to deal with African ethnology, education, history, language, and native affairs, should be established. It was decided to leave the matter for the Committee of Section D to deal with according to circumstances at the Pretoria Session.

15. The New Council: On the basis of Membership provided by Section VI (d) of the Association's Constitution, the number of members of Council assigned to the representation of the several districts for the ensuing twelve months should be distributed as follows:—

Cape Province:	
Cape Peninsula	5
Grahamstown	1
Kimberley	1
Kingwilliamstown	1
Middelburg	1
Port Elizabeth	1
Stellenbosch	1
Transvaal:	
Witwatersrand	7
Pretoria	3
Potchefstroom	1
Orange Free State: (including Basutoland)	
Bloemfontein	2
Natal:	
Maritzburg	1
Rhodesia:	
Bulawayo	1
Mozambique:	
Lourenço Marques	1
	27

REPORT OF THE HONORARY TREASURER FOR THE YEAR ENDED MAY 31ST, 1915.

In presenting the Account of Revenue and Expenditure and the Balance Sheets of the Society for the year ending May 31st, I beg to report as follows:—

The amount received for current subscriptions shows a shortfall of £70 5s.; that received for arrear subscriptions, an increase of £17 10s., a nett decrease of £52 15s.

One of the chief reasons for this decrease is that twenty-eight (28) of our regular subscribers have taken advantage of the new rule *re* Life Members, and the Funds get no advantage whatever from their subscriptions this year.

The Journal has cost a total of £465 14s. 10d., but owing to the very generous contribution of £200 by the De Beers Company towards the cost of printing the proceedings of the Kimberley Meeting, only £265 14s. 10d. shows in the Accounts. As requested at the last Annual Meeting, I have given details of the amounts figuring under sundry charges.

The total of receipts and disbursements show a loss on the year's working of £35 18s. 1d., or, deducting the cost of the May, 1914, Journal referred to last year of £17 7s. 2d., as against £25 16s. 3d. for 1913/14. Considering the state of the country this may be considered satisfactory.

The Endowment Fund has been increased by £140, and now stands at £1,338. During the year the principal amount of this has been invested in 5 per cent. Municipal Bonds, so the interest accruing to General Account will be somewhat increased in the future.

The Medal Fund now stands at £1,429 8s. 5d., a slight increase over last year's amount.

I trust that some satisfactory arrangements may be made at the Annual Meeting by which the annual income of the Society may not be further reduced by the increase in the number of Life Members under the rules adopted last year.

A. Walsh,
Hon. Treasurer.

June 9th, 1915.

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MAY, 1915.

Revenue	£ s. d.	£ s. d.
To Assistant Secretary's Salary ...		120 0 0
,, Rent		30 0 0
,, Journal, nett cost		265 14 10
,, Printing and Stationery.. ...		24 10 0
,, Stamps and Telegrams		13 4 10
,, Sundry Charges—		
Caretaker	6 10 0	
Expenses Annual Meeting ...	26 11 4	
District Expenses, Clause 9, Sec. F	6 4 4	
Engraving Medals	0 15 2	
Audit	5 5 0	
Telegraphic and Registered Addresses	2 1 0	
B.S.A. Meeting	5 7 0	
Library	4 9 9	
Sundry Charges	0 10 1	
		57 13 8
,, Depreciation on Furniture ...		2 17 3
,, Balance to Balance Sheet ...		153 15 0
		£667 15 7

Expenditure	£ s. d.	£ s. d.
By Balance carried forward from 1914		189 13 1
,, Subscriptions, 1914-1915	369 15 0	
,, Arrear Subscriptions	60 10 0	
		430 5 0
,, Interest on Endowment Fund ...		47 17 6
		£667 15 7

BALANCE SHEET AT 31ST MAY, 1915.

Liabilities	£ s. d.
Capital Account	153 15 0
Medal Fund	1,429 8 5
Endowment Fund	1,338 0 0
Subscriptions in advance	19 0 0
	£2,940 3 5

Assets	£ s. d.	£ s. d.
Trustees of Medal Fund		1,429 8 5
Trustees of Endowment Fund ...		1,315 9 0
Cash—		
Standard Bank of S.A., Ltd ...	19 10 9	
Cape Good Hope Savings Bank ...	150 0 0	
		169 10 9
Furniture	28 12 6	
Less Depreciation	2 17 3	
		25 15 3
		£2,940 3 5

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SOUTH AFRICA MEDAL FUND.

Revenue and Expenditure Account *for the year ended 31st May*, 1915.

	£ s. d.		£ s. d.
To C. P. Lounsbury, Grant for 1915	50 0 0	By Balance, 31st May, 1914	1,427 12 1
,, Typing copies of nominations for circulation to Members of Medal Committee	3 0 0	,, Interest on Stock for the year ended 15th May, 1915	55 0 10
,, Engraving Medal	0 4 6		
,, Balance, 31st May, 1915	1,429 8 5		
	£1,482 12 11		£1,482 12 11

ENDOWMENT FUND,

For year ended 31st May, 1915.

	£ s. d.	£ s. d.		£ s. d.
To Revenue Account		47 17 6	By Balance, 31st May, 1915	1,198 0 0
,, Balance—			,, Interest on Fixed Deposit	47 17 6
Invested	1,315 9 0		,, Life Members	140 0 0
Uninvested	22 11 0	1,338 0 0		
		£1,385 17 6		£1,385 17 6

I hereby certify that I have examined the above Balance and Revenue Account with the books, vouchers and Banker's Pass Book relating thereto, and that in my opinion they correctly set forth a true and correct statement of the affairs of the Association as shown by the books thereof.

Hy. Gibson,
Incorporated Accountant,
Certified Accountant (Cape).

Capetown, 9th June, 1915.

EIGHTH AWARD OF THE SOUTH AFRICA MEDAL AND GRANT.

(Fund raised by Members of the British Association in commemoration of their visit to South Africa in 1905.)

Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Union Department of Agriculture, Pretoria, Transvaal, was nominated for the award upon the following grounds:—

"Mr. Lounsbury came to South Africa in 1895 as Government Entomologist in the Department of Agriculture of the Cape Colony, Capetown.

"The greatest service since rendered by him to South Africa arose out of his investigations in regard to the transmission of disease by ticks. As resulting from those investigations he was able conclusively to demonstrate:—

"1. That Heartwater, a virulent disease in sheep, goats, and cattle, is transmitted by the Bont Tick (*Amblyomma hebræum*), and his study of the life-history of this tick had as its result the successful application of dipping as the best method of controlling it.

"2. That Malignant Jaundice of the Dog is transmitted by the Dog Tick (*Hæmaphysalis leachi*), and so he proved that there was a previously unsuspected coincidence between the life-history of this tick and the parasite causing the disease.

"3. That East Coast Fever, the most dreaded cattle disease in the country, is transmitted by the Brown Tick (*Rhipicephalus appendiculatus*) and its allies, and his exceedingly minute investigation of the life-cycle of the Brown Tick opened the way for that system of short-interval dipping which is giving such good results in practice in keeping the tick under control.

"4. That Arsenate of Soda is the essential ingredient in any dip in order that it may be effectual for the destruction of ticks. This demonstration not only simplified the work of cattle-dipping, but also greatly reduced the cost, so that to-day dipping is the recognised method of tick destruction throughout South Africa.

"Sir Arnold Theiler, in his Presidential Address to the South African Association for the Advancement of Science, at its Port Elizabeth meeting, referred to the fact that heart-water at one time rendered the rearing of cattle and small stock almost an impossibility, until Mr. Lounsbury, by his investigation, proved definitely that ticks are responsible for the disease.

"It was through Mr. Lounsbury's efforts that the Smyrna Fig industry in this country was made possible through the introduction of the different varieties of Smyrna Figs (the chief drying figs of commerce). But the introduction of these figs would have had no practical result were it not that Mr. Lounsbury was also successful in introducing into South Africa the

The South Africa Medal.

insect *Blastophaga grassorum*, which carries the pollen from the Capri Figs, and without which Smyrna Figs cannot be fertilised. The Smyrna Fig is imperfect (self sterile), and the structure of the fig is such that it can be fertilised only by means of the *Blastophaga*, which breeds in the Capri Figs, and, coming to maturity when the pollen of the Capri Fig is ready, emerges covered with pollen, which it carries into the Smyrna Figs, and thus brings about fertilisation without which perfect fruit is impossible.

"Although Mr. Lounsbury was not personally instrumental in introducing into South Africa the Ladybird *Novius* (*Vedalia*) *cardinalis* which destroys the Australian bug *Icerya purchasi*—for the *Vedalia* had been introduced into the country a short time before Mr. Lounsbury's arrival here—he at once took up the work of distributing the Ladybird on scientific lines, and with such success that to-day one seldom hears the Australian Bug so much as mentioned as a pest in this country.

"But Mr. Lounsbury's researches in South Africa have been fruitful of good results to other countries as well. In 1898 he found in South Africa a parasite wasp which he at once foresaw would prove of considerable advantage to several other countries for the control of the Black Scale (*Lecanium oleæ*). He found that by means of this parasite (*Scutellista cyanea*), the Black Scale could be kept in complete suppression here, and his suggestion that other lands might share in this benefit resulted in a formal request for assistance in this direction being made by the United States Government. Mr. Lounsbury despatched supplies of the chalcid wasp parasite to America, and colonies thereof were successfully established in the Californian orchards. Similarly, Mr. Lounsbury was instrumental in despatching to the island of Ascension, at the urgent request of the Admiralty, several colonies of one of the South African ladybirds (*Exochomus nigromaculatus*) for the purpose of destroying the Woolly Aphis of the apple tree, which was doing much damage on the island. Some years previously, Mr. Lounsbury had also supplied Ascension with hundreds of specimens of the Ladybirds *Œnopia cinctella*, *Chilomenes lunata*, and *Adalia flavomaculata*, for similar purposes.

"To Mr. Lounsbury's thorough and constant study of the best method of exterminating insect pests is due, more than to anyone else, the credit of the country's being provided with efficient insecticides, fungicides, apparatus and methods associated with the spraying of fruit trees. A very far-reaching development in this work was the discovery that the effectiveness of the Lime-Sulphur-Salt wash over the old California formula was due to the presence of the sulphides of calcium. This at once revolutionised the spraying of orchards for Scale Insects and Plant Diseases, because the elimination of the great excess of lime and salt in the old formula not only reduced the first cost of the wash by one-half, but the resulting freedom of the spraying-mixture from grit, etc., lengthened the life of the spray-

pumps, and made it possible to apply the wash evenly and quickly, and so secure greater efficiency at much less initial cost. Soon these methods began to be copied throughout the world, and to-day the simplified Lime-Sulphur wash is being manufactured on a commercial scale, and is sold by the train-load in America. The practical result in South Africa has been that the simplified Lime-Sulphur wash has secured perfect control over the following pests of primary importance:—

1. White Peach Scale (the work on which led to the discovery).
2. Bryobia Mite on fruit trees.
3. Peach Leaf Curl, etc.

"One of the first steps taken by Mr. Lounsbury on his first arrival in South Africa was to introduce the method of fumigation with hydrocyanic acid gas for the destruction of the Red Scale on citrus trees. The Red Scale is the most important citrus tree pest in South Africa, and at one time it threatened the very life of the citrus industry. Through Mr. Lounsbury's thorough-going work the insect was brought under control, and confidence established in an industry which is doing more than anything else to enhance the reputation of South Africa as a fruit-growing country, and the industry bids fair to assume proportions in course of time that will rival its magnitude in California.

"Mr. Lounsbury also placed South African Plant Import Regulations on a sound basis by introducing the fumigation method for cleansing trees and fruit arriving from oversea. By careful inspection and fumigation he kept the Cape Province (Cape Colony) free from many insect-pests that might otherwise have been introduced, to the great detriment of the whole subcontinent—for instance, Pernicious (San Jose) Scale and Brown Tail Moth, both of which were stopped at Capetown.

"Mr. Lounsbury carried this fumigation method still further when he applied it to the destruction of vermin in Railway Saloons, Schools, Gaols, etc. This entirely new development in fumigation was speedily copied in other parts of the world.

"Needless to say that the work of which the above is an outline, has won for Mr. Lounsbury a world-wide reputation. Even before Union, the Transvaal Government had requisitioned his services, some of the Australian Colonies had sought his assistance, and his aid to California and Ascension against pests persistent in those localities has been mentioned above. Dr. L. O. Howard, the Government Entomologist of the United States, Washington, D.C., paid him a very high compliment when he adopted his methods as the basis of similar investigations in America.

"Mr. Lounsbury's Annual Reports, covering a period of eighteen years, constitute a very valuable series of official as well as scientific records. The following is a list of some of the most important amongst his other publications:—

1. "Fruit Pests," 1896.
2. "Another introduced Scale Pest (*Orthezia insignis*)." *C.G.H. Agric. Journal*, 1898.
3. "Remedy for Mest-wurmen." *C.G.H. Agric. Journal*, 1898.
4. "Two fruit tree beetles." *C.G.H. Agric. Journal*, 1898.
5. "The Codling Moth." *C.G.H. Agric. Journal.* 1898.
6. "Scale insects on ornamental trees and plants." *C.G.H. Agric. Journal.* 1898.
7. "Tampans, or Fowl Ticks." *C.G.H. Agric. Journal.* 1899.
8. "The Wattle Bag-Worm." *C.G.H. Agric Journal.* 1899.
9. "A tick heart-water experiment." *C.G.H. Agric. Journal.* 1900.
10. "Two pine-apple pests." *C.G.H. Agric. Journal.* 1900.
11. "Cyanide gas remedy for Scale Insects." 1901.
12. "Transmission of Malignant Jaundice of the Dog by a species of Tick." *C.G.H. Agric. Journal.* 1901.
13. "Heart-water in calves." *C.G.H. Agric Journal.* 1902.
14. "The destruction of ticks by oil-spraying: Eastern Province experiments." *C.G.H. Agric Journal.* 1902.
15. "Lime-Sulphur-Salt wash for scale insects." *C.G.H. Agric. Journal.* 1902.
16. "Cyanide gas fumigation." *C.G.H. Agric. Journal.* 1902.
17. "The Bryobia Mite." *C.G.H. Agric. Journal.* 1903.
18. "A new oak tree pest: the oak phylloxera." *C.G.H. Agric. Journal*, 1903.
19. "Persian Sheep and Heart-water" (with W. Robertson). *C.G.H. Agric. Journal.* 1904.
20. "Transmission of African Coast Fever." *C.G.H. Agric Journal.* 1904.
21. "Gall worm in roots of plants: an important potato pest." *C.G.H. Agric. Journal.* 1904.
22. "The Codling Moth: Notes on the Life-cycle." *C.G.H. Agric. Journal.* 1904.
23. "External parasites of Fowls." *C.G.H. Agric. Journal.* 1904.
24. "Fruit culture in Argentina." *C.G.H. Agric. Journal.* 1905.
25. "Insect Pests in South Africa." *Science in South Africa.* 1905.
26. "Habits and peculiarities of some South African Ticks." *Addresses and papers. Brit. & S.A. Assoc. for Adv. of Science.* 1905.
27. "Natural enemies of the Fruit Fly." *C.G.H. Agric. Journal.* 1905.
28. "Insect bites and the effects thereof." *The Canadian Entomologist.* 1906.
29. "Ticks and African Coast Fever." *C.G.H. Agric. Journal.* 1906.
30. "Zwart Roest; or, Anthracnose of the Vine." *C.G.H. Agric. Journal.* 1906.
31. "Tobacco wilt in Kat River Valley." *C.G.H. Agric. Journal.* 1906.
32. "The Antestia Fruit Bug." *C.G.H. Agric. Journal.* 1907.
33. "Caterpillars destroying trees." *C.G.H. Agric. Journal.* 1907.
34. "Wooly Aphis and Tobacco Extract." *C.G.H. Agric. Journal.* 1908.
35. "Melon Aphis." *C.G.H. Agric. Journal.* 1908.
36. "Pears and Pear Blight." *C.G.H. Agric. Journal.* 1908.
37. "The Smyrna Fig and its pollinating insect." *C.G.H. Agric. Journal.* 1908.
38. "The Kaffir corn Aphis: *Aphis Sorghi*." *C.G.H. Agric. Journal.* 1908.
39. "Dry rot of the Potato." *CG.H. Agric. Journal.* 1909.
40. "The Codling Moth." *C.G.H. Agric. Journal.* 1909.
41. "Prune rust; a leaf disease of prune, peach, and apricot trees." *C.G.H. Agric. Journal.* 1909.
42. "Miscible oils for spraying." *Agricultural South Africa.* 1910.
43. "Calandra of the Vine." *C.G.H. Agric. Journal.* 1910.
44. "Plasmopara viticola; occurrence in 1910." *C.G.H. Agric Journal.* 1910.
45. "Bitter Pit." *C.G.H. Agric. Journal.* 1910.
46. "The Elegant Grasshopper (*Zonocerus elegans*)." *Union Agric. Journal.* 1912.
47. "Locust Bacterial disease." *Union Agric. Journal.* 1913.
48. "Caterpillar wilt disease." *Union Agric. Journal.* 1913.
49. "The Mally fruit fly remedy: a demonstration of its applicability in towns." *Union Agric. Journal.* 1913.

50. "Pernicious scale: the present position." *Union Agric. Journal.* 1913.
51. "Warble flies." *Union Agric. Journal.* 1914.
52. "Cyanide fumigation of citrus orchards." *Agric. Journ. of S.A.* 1915.
53. "The locust menace." *Agric. Journ. of S.A.* 1915.
54. "Plant killing insects: the Indian cochineal." *Agric. Journ. of S.A.* 1915.
55. "Scale insects." *Agric. Journ. of S.A.* 1915.
56. "The Phoracantha Beetle." *Agric. Journ. of S.A.* 1915.
57. "Cyanide for fumigation purposes." *Agric. Journ. of S.A.* 1915.

After the conclusion of the Presidential Address in the Town Hall, Pretoria, on Tuesday, July 6, 1915, the President, Mr. R. T. A. Innes, handed the South Africa Medal and the award of £50 to Dr. C. F. Juritz, in trust for Mr. Lounsbury, who had left South Africa on a six months' tour in Australia and the United States on recovering from a serious illness. In doing so the President made the following additional statement:—

"The scientific work undertaken by Mr. Lounsbury is both of biological—and what appeals to the people of this country in particular—of economic value. He was the expert who undertook the first extensive investigations into the life cycle of the various tick diseases in South Africa, and so laid the basis of all further work undertaken on similar lines by various investigators. He demonstrated in a series of careful and almost classical experiments the connection between the Bont Tick (*Amblyomma hebræum*) and the disease of Heart-water in goats and cattle. By a series of experiments he proved that the dog tick (*Hæmaphysalis leachi*) was the carrier of biliary fever in the dog. The solution of the problem was of a particularly intricate nature, which speaks highly for our medallist's endurance and keenness in research.

"His investigations on the transmission of East Coast Fever by tick, corroborated and supported by the investigations of other scientists, helped to form the basis of legislation against the disease, and established the introduction of rational dipping both for the eradication of the tick and the disease. Mr. Lounsbury, assisted by the Veterinary Department of the Cape, was responsible for the first systematic dipping experiments undertaken on scientific lines, and the introduction of arsenate of soda, recommended by him, helped to solve the dipping problem in a practical manner. This fact deserves to be especially emphasised, because in these times of rapid progress the inventors of new ideas are easily overlooked or forgotten.

"South Africa is not ungrateful. We, the members of the South African Association for the Advancement of Science, bear in mind that neither Mr. Lounsbury nor any other scientific worker asks for reward. All that the scientist asks is enough to live on modestly, with a sufficiency of leisure to enable him to indulge in his researches, and if he is fortunate in securing the interest of the State in his work he is happy.

"I read recently in an American scientific journal (*Science*, 14 May, 1915) that each scientific worker increases the material wealth of the world by about £20,000,000—or, in other words,

that the prodigious material wealth of the world of to-day, as compared with that of two centuries ago, is due to the inventions and discoveries of 10,000 men. Let us think of Watt, Stephenson, Faraday, and Graham Bell as examples. No wealth could repay our debt to such men. Had the scientist, of which our Medallist is an example, asked for pecuniary reward, he lives in a generous country which has become proverbial for its munificence to individuals, and he might have fared well. There are but few books which do not contain references to our South African millionaires. Our rewards have been prodigious, but, candidly, I think that in bestowing them our heart has triumphed over our head—that we have been too lavish, and that our generosity has lacked discrimination. It is therefore with some pride that I take part in this ceremony, which marks the appreciation of our Association and of his colleagues in scientific research."

The President thereupon handed the medal and cheque to Dr. Juritz, and said:—" Will you please transmit this medal to Mr. Lounsbury, and wish him in our name a complete restoration of his health and every success in his further researches, which we will follow with sympathetic interest."

Dr. Juritz, on behalf of Mr. Lounsbury, thanked the Council of the Association for the award and the President for his kindly references to Mr. Lounsbury's work in making the presentation. He promised to convey the award and the President's good wishes to the Medallist in due course. He referred to his association with Mr. Lounsbury in the professional branch of the Cape Department of Agriculture, an association which had begun over a score of years ago, and expressed the particular pleasure he felt in accepting the medal on behalf of one who had served his adopted country so well.

Previous Recipients.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., M.D., Bacteriologist to the Transvaal Government, Pretoria.

1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood, Kenilworth, Cape Division.

1910. *Capetown.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Capetown.

1911. *Bulawayo.*—Louis Péringuey, D.Sc., F.E.S., F.Z.S., Director of the South African Museum, Capetown.

1912. *Port Elizabeth.*—Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E., of Lovedale Observatory, C.P.

1913. *Lourenço Marques.*—Arthur William Rogers, M.A., Sc.D., F.G.S., Assistant Director of the Union Geological Survey, Capetown.

1914. *Kimberley.*—Prof. Rudolf Marloth, M.A., Ph.D., Capetown.

ASSOCIATION LIBRARY.

The following publications are regularly filed at the office of the Association, Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town, and are available for perusal by members daily.

General Science.

Proceedings of the Royal Society of Edinburgh.
Transactions of the Royal Society of South Africa.
Memoirs of the Royal Society of South Australia.
Transactions of the Royal Society of South Australia.
Proceedings of the Royal Society of Victoria.
Proceedings of the Royal Society of Canada.
Papers and Proceedings of the Royal Society of Tasmania.
Proceedings of the Royal Institution of Great Britain.
Proceedings of the Royal Philosophical Society of Glasgow.
Journal of the Royal Society of Arts.
Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften.
Servian Royal Academy of Sciences:
    Comptes rendus.
    Year Book.
Michigan Academy of Sciences: Reports.
Bulletins of the Chicago Academy of Sciences.
Atti della Reale Accademia dei Lincei, Rome.
Kungl. Svenska Vetenskapsakademien:
    Handlingar.
    Årsbok.
Koninklijke Akademie van Wetenschappen, Amsterdam:
    Proceedings of the Section of Sciences.
    Verhandelingen.
Revista de la Real Academia de Ciencias de Madrid.
Report of the British Association for the Advancement of Science.
Report of the Australasian Association for the Advancement of Science.
Proceedings of the American Association for the Advancement of Science
Atti della Società Italiàna per il progresso delle Scienze.
Cambridge Philosophical Society:
    Transactions.
    Proceedings.
Memoirs and Proceedings of the Manchester Literary and Philosophical Society.
Proceedings of the American Philosophical Society.
University of Virginia: Philosophical Society Bulletins.
Science Reports of the Tôhoku Imperial University.
Annals of the New York Academy of Sciences.

Proceedings of the American Academy of Arts and Sciences.
Transactions of the Connecticut Academy of Arts and Sciences.
Medelanden från K. Vetenskapsakademien Nobelinstitut.
Proceedings of the California Academy of Sciences.
Transactions of the Academy of Science of St. Louis.
Proceedings of the Academy of Natural Sciences of Philadelphia.
Archives Néerlandaises des sciences exactes et naturelles.
Annaes scientificos da Academia polytechnica do Porto.
Proceedings of the Rhodesia Scientific Association.
Memoires de la Société de physique et d'histoire naturelle de Genève.
Det Kongelige Norske Videnskapers Selskaps Skrifter.
Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger.
Comptes rendus des séances de la Société de physique et d' histoire naturelle de Genève.
Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.
Bulletin of the Imperial Institute.
Transactions and Proceedings of the New Zealand Institute.
Annual Report of the Smithsonian Institution.
Annual Report of the Smithsonian Institution (United States National Museum).
Annals of the Transvaal Museum.
Annals of the Natal Museum.
Memoirs of the Queensland Museum.
Field Museum of Natural History Publications.
University of Pennsylvania Museum Journal.
Bulletin of the Public Museum of Milwaukee.
Records of the Albany Museum.
Knowledge.
Science.

Chemistry, Metallurgy, and Geology.

Journal of the Chemical, Metallurgical, and Mining Society of South Africa.
Kungl. Svenska Vetenskapsakademien; Arkiv för Kemi, Mineralogi, och Geologi.
Transactions of the Geological Society of South Africa.
Journal of the Geological Society of Tokyo.
Geological Survey of New South Wales:
- Records.
- Memoirs.
- Mineral Resources.

Bulletins of the Geological Institution of Upsala.
Abstracts of Proceedings of the Geological Society, London.
Bulletins of the Wyoming State Geologist.
United States Geological Survey:
- Bulletins.
- Professional Papers.

Mineral Resources.
Annual Reports.
Union of South Africa Mines Department, Annual Reports.
Egyptian Ministry of Finance: Geological Reports.
Geological Survey of Western Australia:
Annual Progress Reports.
Bulletins.
Journal of Industrial and Engineering Chemistry.
The Chemical News.
The Mineralogical Magazine.

Meteorology.

Quarterly Journal of the Royal Meteorological Society.
Bulletins of the Mount Weather Observatory.
United States Department of Agriculture: Monthly Weather Review.
Observatorio Campos Rodrigues:
Relatorio.
Resumo mensal.
Egyptian Ministry of Finance: Meteorological Reports.

Agriculture.

Annali della Regia Scuola superiore agricoltura di Portici.
International Institute of Agriculture, Rome:
Bulletin of Agricultural statistics.
Bulletin of the Bureau of Agricultural Intelligence and of Plant Diseases.
Massachusetts Agricultural Experiment Station:
Annual Reports.
Bulletins.
Agricultural Journal of the Union of South Africa.
Agricultural Gazette of New South Wales.
United States Department of Agriculture Experiment Station Record.
Journal of Agricultural Research.
Rhodesia Agricultural Journal.
Department of Agriculture, New South Wales, Science Bulletins.

Biology and Physiology.

Bulletin de la Société Imperiale des naturalistes de Moscou.
Kungl. Svenska Vetenskapsakademien:
Arkiv för Botanik.
Arkiv för Zoologi.
Journal of the Linnean Society, Botany.
Bulletin of the Wisconsin Natural History Society.
The Medical Journal of South Africa.
University of California: Publications in Botany.

Missouri Botanical Gardens:
Annual Reports.
Annals.
Smithsonian Institution (United States National Museum):
Contributions from the United States National Herbarium.
Bulletins of Royal Botanic Gardens, Kew.
The Australian Zoologist.

Entomology.

Report of the South African Central Locust Bureau.
Zeitschrift für wissenschaftliche Insektenbiologie.

Astronomy, Mathematics and Physics.

Royal Astronomical Society:
Memoirs.
Monthly Notices.
Harvard College Astronomical Observatory:
Circulars.
Annals.
Union Observatory Circulars.
Observatoire Royal de Belgique; annuaire astronomique.
Bulletins of Khedivial Observatory, Helwan, Egypt.
British Astronomical Association:
Journal.
Memoirs.
Lick Observatory Bulletins.
Journal of the Astronomical Society of India.
Proceedings of the Western Australian Astronomical Society.
Kungl. Svenska Vetenskapsakademien: Arkiv för Matematik, Astronomi och Fysik.
Proceedings of the London Mathematical Society.
Tôhoku Mathematical Journal.
Die Tätigkeit der physikalisch-technischen Reichsanstalt, Charlottenburg.
National Physical Laboratory, Middlesex:
Collected Researches.
Reports.
Universidad Nacional de la Plata:
Contribucion al estudio de las Ciencias fisicas y matematicas.
Proceedings of the Physical Society of London.

Political Economy and Social Science.

United Empire.
International Institute of Agriculture, Rome: Bulletin of the Bureau of Economic and Social Intelligence.

Geography, Oceanography and Hydrography.

Società Italiana per il progresso delle Scienze: Comitato talassografico.
Bollettinos.
Memorias.
The Geographical Journal.
Bulletin of the American Geographical Society.
United States Geological Survey: Water Supply Papers.
Egyptian Ministry of Finance: Survey Department Papers.
Istituto di geografia fisica e vulcanologica della R. Universita di Catania: pubblicazioni.

Engineering.

Proceedings of the American Institute of Electrical Engineers.
Journal of the South African Institute of Engineers.
Transactions of the South African Institute of Electrical Engineers
Proceedings of the South African Society of Civil Engineers.

Technology.

Patents for Inventions: Abridgments of Specifications.
The Illustrated Official Patents Journal.

Anthropology.

Journal of the African Society.

Archæology.

Bulletins of the Archæological Survey of Nubia.

PRESIDENT'S ADDRESS.

ADDRESS

BY

ROBERT THORBURN AYTON INNES, F.R.A.S., F.R.S.E.

PRESIDENT.

Excluding the purely formal meeting of 1905, in which year we joined forces with the visiting British Association for the Advancement of Science, this is the second session of the Association to meet in the Transvaal and the first to meet in Pretoria. Our Association was started in 1903 at Capetown, and in 1904 the meeting was held in Johannesburg, but on that occasion one day was spent in Pretoria. This year we hold our meeting in what is now the Administrative Capital of the Union, but we are invited to spend one day in Johannesburg, visiting the Crown Mines, when visitors will have a favourable opportunity of seeing the conditions under which our staple industry is conducted, especially with regard to modern views on hygiene and the preservation of life.

The calm atmosphere of our Association is especially suitable for discussions upon the broad principles underlying polity.

In the present times these principles are being profoundly modified; old standards of government seem to be weakening day by day, and our Association affords a common ground where tendencies can be examined for what they are worth, instead of through the distorting lenses of party passion.

The list of papers bearing upon politico-sociological questions read before our Association since its inception is too long for me to quote at length. At our first meeting in 1903, Professor Fremantle read a paper on the "Sociology of Comte, with special reference to the Political Conditions of Young Countries," and Mr. Basil Williams one upon "Recoupment and Betterment." In 1906 Dr. Watkins gave a Sectional Presidential Address upon "Economic Waste," and in 1914 one upon the "Constitution of the Senate." We also have had papers on "Proportional Representation" by Mr. William Cullen, "Municipal Trading" by Mr. J. M. P. Muirhead, "State Socialism or Nationalisation" by Dr. Leech, etc., etc. I see that amongst the papers being read at this Congress there is one by Mr. Frank Flowers upon the "Constitution of the Senate," evidently in continuation of Dr. Watkins' paper; this appears to be a subject well worthy of discussion, as the Senate, as at present constituted, will automatically come to an end in 1920. Other papers, by Mr. R. Kilpin and Dr. Brown, deal with the subject of "Proportional Representation."

War and Science.

We meet this year under extraordinary circumstances, during a period of war unequalled in the history of mankind in its extent and intensity. A superficial view would be that our Association has nothing to do with wars at any time, and should ignore the present war. This view would be entirely wrong. The war touches humanity at every point, in every interest. I am therefore going to deal with it, but in such a way that no one could say to which side my sympathies lean. I have, like everyone else, very decided views upon the rights and wrongs of the war, but these concern one of the aspects with which we as a scientific body have nothing to do.

A certain school of thought—not particular to any one nation—has praised the value of war as a discipline, and even as a moral force. Another school looks upon war as a curse for which no defence is possible. Science is impersonal, and looks merely to facts. Yet Science cannot but feel degraded when it finds so great a part of its recent advances applied so freely and almost solely as aids to the destruction of human life. The pre-eminent inventions of our present generation —wireless telegraphy, the airship, the flying machine, the submarine, thermite, and other allied heat producers—seem to have found their culmination in use in war. How different is this from the Scientist's ideal—the most altruistic possible—the lightening of the burdens of humanity by the mastery of natural forces—the transformation of inanimate power to relieve man-

kind from arduous work—the conquest of pain and disease—the improvement of agriculture—and, by no means least, the enlargement of the human mind. Greek culture—that extraordinary efflorescence of a limited community of small cities, which we prize so highly to-day, and whose lesson seems to be valid for all time—we are told was only possible because the Greek civilisation was built upon slavery; the helot was the pivot on which it turned. The scientist looks forward to a period of leisure and culture equally founded upon a slavery, but not upon the unwilling slavery either of man or beast, but upon the willing slavery of machinery and of the powers of nature harnessed for use.

An increasing and unfaltering search for truth, with a belief in the betterment of humanity through knowledge, is the ethical basis of Science, and none other. If Science could only serve material ends—the increase of money—profit, or serve to rivet the domination of one State over another—then it would be worthless, nay, it would be unclean.

We perceive to-day that when any one nation deliberately uses the resources of Science as an aid to war, a burden of terrible import is thrown upon other nations. And herein is another apparent great evil of Science, because its advance makes war both more terrible and more destructive. I say an apparent evil, because if it is not controlled it will lead to exhaustion, and so limitation will have to come by necessity. I believe that in earlier ages the individual, or at least the family, the patriarchal group, was to a great extent, like a nation is now, each a law unto itself, and it was only as weapons got more expensive and deadly that the small group was willing to abandon the right of private revenge or redress. In yet later ages the baron in his great castle could defy the king, but the invention of the cannon and the control of the manufacture of gunpowder by the king, made even the most powerful barons willing to accept the king's peace. To-day we would not tolerate any man or group of men turning their buildings into fortresses; to-morrow, I hope, I believe, that nations, or a federation of nations, will likewise refuse to allow any other nation or group of nations to arm themselves to such an extent that it or they can become a menace to the peace of the rest of the world.

Organisation.

There is another and more positive lesson for us in the present war. It shows the power of organisation. We see two Empires, but roughly one—the Germanic nation—at war with four other great nations, which has so developed its resources and organised them, that it can stand the strain of such a war that 25,000,000 picked men have already been in the field. However deplorable this may be from ethical and economic points of view, it at least does show what Science and Organisation can do to-day. I suppose that, one way and another, 50,000,000 of the human race are either fighting or supplying food and munitions of war to the combatants. And

no sign of exhaustion is as yet clearly discernible. When we remember that war in the olden days was conducted with small armies and only during a portion of the year, we realise the maleficent power that Science has placed in the hands of mankind. It needs careful regulation. This power for evil might only have been potential, it might have remained undeveloped; but we have found to our loss that at least one nation has developed and organised itself, by the aid of Science, to such an extent that it dares to declare itself independent not only of the power, but even of the opinions of the rest of the world.

The lesson will not be lost. If the deliberate organisation of a single nation can result in such power, then every nation must organise. Not necessarily organise for war, for death; but organise for peace, for life.

Laissez faire passed into twilight when the Great War commenced. We have to turn our eyes in the direction of the rising sun of an organised humanity, of which we perceive the dawn already. Then the Advancement of Science will surely have no sinister meaning. We pray that the Advancement of Science will be identical with the advancement of humanity.

Progress of Astronomy.

I am perhaps fortunate in belonging to a branch of Science which has nothing to do with war. Therefore the astronomer can regard war with a sense of detachment; and to those who know the stars, the immensity, the eternity of the universe, its increasing grandeur, war seems trivial and foolish—the work of unbalanced minds.

I spoke of one of the aims of Science as the enlargement of the human mind. Although every branch of knowledge—a word which I take to be nearly synonymous with Science (Science being co-ordinated knowledge)—leads to the extension of the human mind, to-day Astronomy has no other real use. We know that clocks are corrected through the observations of the stars, and that the sun and stars must be observed by navigators, but preparation for these practical applications form a very trifling portion of the activities of astronomers. The very perfection of that part of Astronomy reduces it to a sort of automatism—it all but goes by itself. To-day the astronomer wants to find out the dimensions of the sidereal system—the extent of the Universe—the structure and arrangement of the stars in space—their relations to each other—the interpretation of their spectra—the dynamics of the Universe—the cause of variable stars. The solutions of any or all of these questions can hardly have any material effect upon mankind—the effect is spiritual and emotional—man is proud to find that he can plumb space to its uttermost depth; he presumes that the germ of the future which was conceived in the past is taking its form to-day, and that the process is continuous, and that as to-day he can predict tides and eclipses, so with greater knowledge he will in the future be able to predict the course of the sun amongst

the stars and the future conditions of the planet upon which he has his being.

The Distances of the Stars.

The problem which will be more closely discussed in this address is that of the distance of the stars. The most direct way of finding these is by the parallactic displacement of the stars caused by the motion of the earth round the sun. In this enquiry the Union can have a local pride, as the first parallax* certainly found was that of Alpha of Centaurus by Henderson, the Cape Astronomer. The late Sir David Gill, our first President, continued Henderson's work, and perhaps one might say finished it in that form. Gill was an organiser, and when the parallax campaign, initiated by himself and completed with the aid of Dr. Elkin and others, had come to an end, it was apparent that the most direct† method of finding parallaxes which was available would only yield a small crop, because the stars are at such enormous distances from the sun that the available base-line for measurement, the diameter of the earth's orbit, some 186,000,000 miles, or 300,000,000 kilometres, is vanishingly small at the distance of all but a few near stars. Alpha Centaurus is the nearest known, and almost certainly the nearest to the sun, yet at its distance the diameter of the earth's orbit subtends an angle of but 1½ seconds of arc—an angle which is described by the minute hand of a clock in a four-thousandth part of a second of time. An angle so small is difficult to observe directly with accuracy, so that at best the measures must become differential—that is, the stars are measured from neighbouring stars supposed to be at a much greater distance away; such stars are called comparison stars.

Professor Eddington estimates that there are thirty stars with a parallax of 0".20 or greater, of which nineteen are already known. This means that within a distance nearly four times as great as that of Alpha Centaurus there are but thirty stars in all. This is the limit of visual work such as was done by Gill, but photographic methods, especially with the enormous telescopes used in America, carry the direct attack further.

The delicacy, or, if you prefer, the accuracy, of any measurement is limited by its probable error. The probable error of a parallax measured visually under good circumstances (such as with the Cape heliometer) is about 0".10 (a tenth of a second of arc), and this is already, small as it is, a quantity larger than the quantity to be measured except in the cases of a hundred or so stars. The same method of parallactic displacement of stars on photographic plates has a much smaller probable error. The

* But not the first announced. Bessel in 1838 announced the measurement of the parallax of 61 Cygnus two months earlier than Henderson whose delay was caused by his removal to Europe.

† The only direct parallax found was that of α Centaurus, by Henderson. All other parallaxes of any certainty depend on an indirect method involving the assumption, nearly true, that all the stars with a few exceptions have very minute parallaxes.

most recent determinations made with the great telescopes of America, and in particular the 40-inch refractor of the Yerkes Observatory, have a probable error of about 0".01, or ten times less than the usual visual method, and Dr. Van Maanen, using photographs taken with the 60-inch reflector of the Mount Wilson Observatory, has reduced this probable error to 0".006, or about a hundred and seventieth part of a second of arc. As regards the measurements of small quantities this is a wonderful achievement, but delicate as these measurements are, they are too coarse to tell us much about the distances of the stars.

Let us consider several recent sets of parallax measures:—

1. Van Maanen's list of five stars is as follows:—

Star.	*Parallax.* "	*Probable Error.* "
96	0.026	±0.007
672	—0.009	0.004
1549	0.001	0.002
2921	0.078	0.006
3233	0.003	0.010

2. In two recent lists we find parallaxes for 61 Cygnus, the star for which Bessel first found a parallax.

Authority.	*Parallax.*	*Probable Error.*
Miller, 24-in telescope, Sproul Observatory ...	0".301	±0".010
Slocum & Mitchell, 40-in. telescope, Yerkes Obs.	0".272	0".005

The negative parallax in Van Maanen's list would mean that the star was actually more distant than its comparison stars, which is at least unlikely, and in two other cases it will be seen that the parallaxes found are smaller than their probable errors. Somewhat similarly, in the case of 61 Cygnus, although the two parallaxes found agree very well, they differ by much more than their probable errors.

3. In the recent most considerable list of stellar parallaxes published (Slocum & Mitchell, *Popular Astronomy*, 1914 March), out of twenty-eight results, eight are negative parallaxes* and another four are smaller than their probable errors; yet the list is one of stars selected for large proper motion or some other peculiarity which indicated a measurable parallax.

These three sets show us that, valuable as the photographic method is, it is to be feared that it will also soon work out its rich lodes. So it does not take us much further. In this way the direct attack by parallactic displacement will reveal perhaps some one or two hundred parallaxes; but we would learn nothing as to the distances of the great mass of stars, except what we already know, namely, that the distances are tremendous.

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*In this list the parallaxes of the two components of South 435 (Σ'443) [3h. 40m. + 41°] are measured. These two stars form a physical system as they are travelling together through space with an annual proper motion of 1".4 in the direction of 149°. The parallaxes found are—

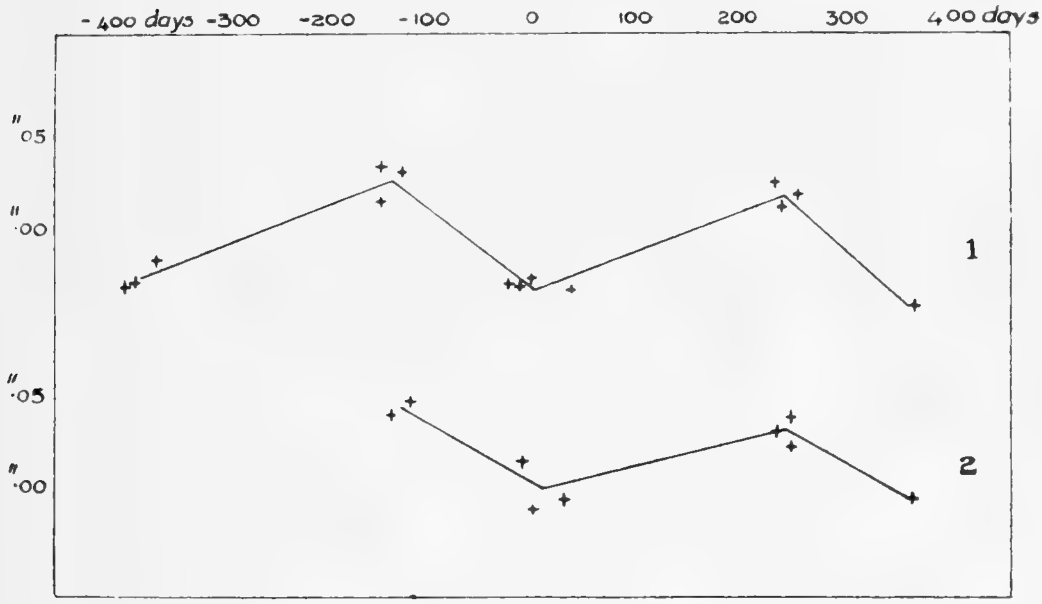
1st star.	—0".016	± 0.011
2nd star	+0".010	± 0.008

which are contradictory, because they signifiy that the first star was more distant, and the second star nearer, than the comparison stars. It is likely enough that even, photographically, our present limit is about 0".03, corresponding to a distance of about 30 radials.

Fortunately there is an indirect method of attack which, in the course of time, will tell us the distances of all the stars.

Basically this method depends upon a knowledge of the proper motions of the stars. If by its annual motion around the sun, the earth causes the stars to be displaced, it is obvious that the progressive motion of the sun through space must cause a progressive displacement. If for the moment we assume the stars to be at rest, they will seem to suffer two displacements—one purely periodic in a year, the other progressive, due respectively to the earth's orbital motion and the sun's motion through space.

Here is a diagram of such a double motion, which was originally published by Mr. Slocum. It plots the measures exactly made in the case of θ Perseus and its companion.



Parallax observations of θ Perseus (1) and its companion (2) (after Slocum, *Popular Astronomy*, May, 1915).

That the lines are zigzags is due to the parallactic displacement caused by the orbital motion of the earth, whilst the progressive movement is due to the motion of the sun—at least in part; wholly if the stars were stationary in space—partly if, as is to be expected, both stars and the sun are in motion. The crosses mark the actual observations made, so that at a glance one can see both the scale of the parallax and the inevitable uncertainties of observation.

The earth's orbital motion being periodic has no cumulative effect, but the sun's progressive motion is cumulative. The amplitude of the earth's periodic motion is about 300,000,000 kilometres, and all the best and most recent results show that the sun is moving through space with a velocity of about 18 kilometres a second; hence in a year the sun, and with it, of course, the earth and the rest of the Solar System, move over a distance of 550,000,000 kilometres; roughly this is already twice the earth's annual displacement, and, as already stated, it is cumulative; thus, in six years, the progressive displacement is already

eleven times the earth's periodical displacement, and the gain is continuous. Hence the mere lapse of time will tell us the distance of the stars, but the problem is complicated because the proper motions of the stars are not mere reflexes of the sun's proper motion; the stars themselves are also in motion, so that a process of unravelling is necessary. Without any unravelling, but by simple averaging, the elder Herschel found out that the sun was travelling in the direction of the constellation Hercules. At Capetown, in 1905, Professor Kapteyn announced his discovery that the proper motions of the stars divided themselves into two distinct drifts. The elder Boss found that the proper motions of a widely-spread group of stars converged to a point. The same astronomer also found, from a study of the proper motions, that there was a marked relation between the amount of proper motion and a star's spectrum.

Investigations based upon proper motions—the thwart or across the line of sight motions—were powerfully aided by spectroscopic results, and especially by the application of the Doppler principle, which tells us almost directly the radial velocity of the star, or its motion in the line of sight. The interpretation of stellar spectra is far from complete, and its problems will not be discussed to-night. The broad facts are that stellar spectra, with a few exceptions, fall into four great classes, which may be called the helium stars, the hydrogen stars, the metallic stars, and the carbon stars, in which the gradation from one class to another is so well marked that it is very plausibly assumed that a star of one class can in the course of time change into its contiguous class, and from that into its next class. At present it is assumed that the helium class is degrading or cooling into the hydrogen class, and that the hydrogen class is similarly approaching the metallic class (in which our sun is), and that later the metallic class will degrade into the carbon class, and that, finally, the carbon class will cool down and become dark stars. This continuous degradation is a convenient *memoria technica,* but it is not based upon any facts. Sir Norman Lockyer, by a closer study of spectra, asserts that there is both a descending and an ascending scale. The assumption that there are the dark stars above referred to is unsupported by any fact. But to-night we are only concerned with spectrum analysis as an aid to interpreting the proper motions of the stars. Radial velocities fully confirm the motion of the sun through space as disclosed by the proper motions. The recent spectroscopic determinations of the direction and amount of the solar motion made by Dr. Campbell in America, and by Messrs. Hough and Halm at the Cape, agree within a reasonable margin with the determinations of Newcomb and Boss, which are based in proper motions. Further, as with the proper motions, it is found that as the stars degrade from helium to hydrogen to metallic to carbon spectra, their velocities increase. Professor E. C. Pickering and others have shown how certain species of stars aggregate in certain parts of the sky. Thus the helium stars are only found near the Milky Way, that

great girdle of stars which is the framework of the sidereal system. The direct measurement of parallaxes, and the smallness of their proper motions, both indicate that the helium stars are enormously distant; and conversely, that stars near us are generally of the metallic spectrum class. Besides the Taurus group of converging stars found by Boss, several other groups, with members spread all over the sky, have been found. The stars in these groups appear to be moving with nearly equal and parallel velocities through space. It is evident that once a star is grouped correctly, and the parallax or distance and velocity of any one star in its group is known, we can also determine its distance. Unfortunately the Doppler principle, by which astronomers determine the radial velocities of the stars, is somewhat limited in its application. In the helium and hydrogen classes the lines of the spectrum are few, and are difficult to measure, and in all classes it is only possible to measure the displacements of the lines of the bright stars. Even if we anticipate improvements in the art of spectrography, it would seem impossible to obtain spectroscopic data in the form required for more than twenty or thirty thousand of the brighter stars. Therefore, although spectroscopy will be a useful ally, its help is limited.

Let us now collect the data which are at the astronomers' disposal for finding the distance of the more distant stars. The most important datum is the star's proper motion. This is compounded of the reflex of the sun's motion and of the star's own proper motion, which latter may be eliminated by a process of judgment by assuming that the star is an average member of its group and spectral class, or that it belongs to one or other of Kapteyn's two drifts. Although in individual cases these indications may be very erroneous, yet in the gross they are permitting astronomers to classify the stars into manageable groups.

What is wanted is a better knowledge of the proper motions of the stars. Unfortunately at present these are not well known except for perhaps 10,000 of the brighter stars. Hitherto, the finding of the proper motions of the stars has been slow, arduous and expensive work. At least ten meridian observations, spread over half a century, were essential, and each meridian observation cost about 20s., and meridian observations can only be made of the brighter stars—of perhaps 100,000 out of 1,000,000,000 stars now within the reach of the largest telescopes, or of one star in every 10,000. This proportion is altogether too one-sided. Hence astronomers hailed the advent of the photographic dry plate. An organisation for a *Carte du Ciel* was formed, in which our first President, the late Sir David Gill, was one of the chief promoters, and this scheme has now been at work for twenty-eight years; but, so far, the first *Carte* is far from complete. When completed in ten or twenty years time, we may expect it to furnish us with precise positions of some 3,000,000 stars (or of about 1 star in 300, still a very small proportion). We will not know the proper motions of these stars. To achieve that, another *Carte du Ciel* must be prepared, so that we must expect

another half-century to elapse before we are in possession of these 3,000,000 proper motions. Again, the labour, and with it the cost involved is enormous, and will probably be in the neighbourhood of 10s. a star.

The drawback to these two methods of obtaining proper motions is the necessity for defining the exact position of each star at different epochs, whilst what we want is not its exact position, which is difficult to define, but its change of position—that is, its proper motion. At the beginning of this century it had been suggested that there was no necessity to measure the places of all the stars on photographic plates, but that if pairs of plates were examined in the stereoscope, those stars which had moved relatively would stand out in relief; alternatively, that if pairs of plates were superimposed, those stars which had moved by proper motion would easily be picked out. These suggestions were tried, and led to the discovery of a few proper motions, but the method was not workable on a large scale, mainly because of fatigue or strain upon the eyes. A third alternative was discovered by Dr. Pulfrich, of Jena, and described by him as a blink method. By this method the pair of plates to be examined is placed side by side, like the pictures in a sterescope, but they are examined with one eye through an optical and mechanical arrangement which rapidly lets the eye rest first on one plate and then on the other, so that in one second the eye has looked at each plate separately three or four times. This blinking makes the eye wonderfully sensitive to the slightest shift upon the plates. If one star relatively to its neighbours has shifted a hundredth of a millimetre upon a *Carte du Ciel* plate, the change is not only unmistakeable, it is obtrusive.. This blink-method revolutionises astronomy of position as regards the stars. Both with the meridian observations and the *Carte du Ciel* measurements, each star had to be dealt with separately. In the blink method the stars are dealt with in groups Indeed, one can say that it is easier to deal with 1,000 stars by the blink method than with one by the other methods. All that the blink method requires is pairs of plates separated by as long intervals as possible. A few weeks ago Mr. Hough (H. M. Astronomer at the Cape) placed in Mr. Voute's and my hands a pair of plates with a time interval of nearly twenty-three years. There were about 10,000 stars on the two plates, but in a few hours we were able to announce that only twenty of these showed proper motion—the rest were fixed stars—and we were able to find the proper motions of many stars which were so faint that even the great *Carte du Ciel* would not have included them. Since then further pairs of Cape plates have been placed at my disposal with intervals of sixteen to eighteen years; the results confirm the earlier experience. We can therefore clearly state that astronomers have now a weapon of attack which will in the course of time reveal to them, without arduous or expensive labour, the proper motions of all classes of stars from the brightest to the faintest. This will lead to a knowledge of the structure of the sidereal

universe which a few years ago seemed unattainable. The immensity of the task when tackled by the old methods seemed so great, and the consequent delay so inevitable, that Kapteyn proposed that astronomers should concentrate their attention on certain selected areas which might be taken as representative samples of the whole sky.

A rude analogy will perhaps help us. The old way was something like studying the condition of England by means of a "Burke's Peerage" or a "Who's Who." Kapteyn proposed as better a limited number of selected areas, some urban, some rural; but the blink method will easily cover the whole area and permit an exact census to be taken.

The present state of astronomical science is one of great activity, but I have only time to make some brief references. The activities of the Union Observatory, an institution which was originally started by our Association, call for some mention. The late Mr. Franklin-Adams planned a photographic chart of the whole sky, and more than half of the plates were taken at the Union Observatory. These were forwarded to the Astronomer Royal at Greenwich, and are undergoing examination. Some of the first results of this examination have been published in the "Memoirs of the Royal Astronomical Society." Counts of the stars on these plates have been made by Messrs. Chapman and Melotte,* from whom the following figures are taken:—

Galactic Latitude.	Plates taken in S. Africa.	Plates taken in England.
0° to 15°	988,000	515,000
16 to 30	616,000	383,000
31 to 50	406,000	230,000
51 to 90	307,000	145,000

This little table invites two comments—one is that the purity of the atmosphere has resulted in many more stars (nearly twice as many) being found on the plates taken at the Union Observatory; the other that the richness of the plates decreases more or less uniformly as the Galactic Plane—the Milky Way—is left. Chapman and Melotte also give this table, showing the total number of stars in the sky, arranged according to magnitudes:—

Magnitude.	Number.
2.0	38
3.0	111
4.0	300
5.0	950
6.0	3,150
7.0	9,810
8.0	32,360
9.0	97,400
10.0	272,000
11.0	698,000

* *Mem. R.A.S.* **60** [4].

Magnitude	Number
12.0	1,660,000
13.0	3,680,000
14.0	7,650,000
15.0	15,500,000
16.0	29,500,000
17.0	54,900,000

So actually, the Franklin-Adams plates locate for reference at any time about 100 million stars, and these may be said to be all the stars known to astronomers. Special plates taken with the largest telescopes indicate a much larger number of stars—perhaps 10 to 15 hundred million in all. It will be noticed that the ratio from one magnitude to another, which is larger than 3 at the beginning of the table, progressively decreases, and is already less than 2 for the 15-16 magnitude; hence the authors conclude

> That modern photographic telescopes penetrate to a distance at which the stars begin to thin out fairly quickly either really or by absorption.

Variation of Latitude.

Since March, 1910, and until December, 1914, the Union Observatory has, aided for some years by a subsidy from the International Geodetic Bureau, taken part in a scheme of observations for measuring the variation of latitude. I must be brief, and will only say that the question at issue was: "Is this variation common to the whole globe, or is it in part or wholly due to the elasticity of the Earth, so that the deformation in the northern hemisphere might be different from that of the southern hemisphere?" The result of our observations to March, 1913, proves that in the variation of latitude the Earth moves as a solid. In Dr. Albrecht's own words:—

> From this series of observations we can deduce an interesting confirmation of the result, previously obtained, that the values of the quantities x, y, and z deduced from observations made in the northern hemisphere, can be applied without any modification to the variation of the latitude in the southern hemisphere.*

Gravitation.

For upwards of half a century it has been known that the law of gravitation seems to be insufficient to account for all the planetary motions—the most conspicuous exception being the motion of the perihelion of Mercury's orbit—and it has been found more recently that it is impossible to reconcile the Moon's motion with gravitation. Recently Professor Larmor and Mr. H. Glauert have proved that a certain amount of these irregularities are due to variations in the length of the day; Glauert finding that the length of the day has increased by a hundredth of a second in a third of a century. This means that as compared with a third of a century ago, the year will appear to be about 3½ seconds longer. Such a change, because of our methods of determining time, will be most clearly reflected in the motion of the 1st Satellite of Jupiter, whose eclipses can be observed with an accuracy of about 1 second,

* *Rapport sur les Travaux du Bureau Central en* 1914, page 6.

and whose motion is the most purely periodic that is known. Since 1908, every visible eclipse of this satellite has been observed at the Union Observatory, so that in the course of time we may expect that our observations may assist in the solution of an obscure problem.

In dealing with the structure of the sidereal universe, or in a smaller way with the dynamics of a star-cluster, it is often tacitly assumed that gravitation is the only force at work. That gravitation is not universally applicable we see in the solar system in the phenomena of comets' tails, and even more so in the disintegration and disappearance of periodic comets such as those of Biela and Holmes. Many double stars are undoubtedly subject to the law of gravitation in all its purity, but in far many more gravitation appears to be at most only only a secondary force (thus in the case of double stars of which both components are of the helium type, there do not appear to be any signs of gravitative action between the two stars.* It is true that stars with variable radial velocities have been found spectroscopically, and their orbits deduced by purely gravitational principles, but in many of these cases it is not indubitably certain that the shift in the lines of the spectrum is due to recession or approach. The difficulty is that in the so-called earlier type of stars, it is found that the H and K lines of calcium do not share in the variable motion on which the binary orbit is based. The interpretation of spectra—the contradictory behaviour of different lines, their thickness and intensities—still provides problems to be solved. In this connection one must refer to the illuminating papers by Dr. Nicholson on the relation between atomic structure and the lines in the spectrum. Nicholson's work makes much use of the spectra of nebulæ, in which we see matter under simpler conditions than is possible on Earth. At this meeting Professor Malherbe is reading a paper upon "Atoms, Old and New," which will go further into this subject than is possible here.

Organisation of Astronomy.

In the earlier part of this address I dwelt upon the power of organisation under scientific direction. I am tempted to develop the subject, limiting my example of organisation to the science of Astronomy, which is truly international in its aims. Astronomers are scattered all over the world, and pursue their work independently of the people amongst whom they live, and who provide the money necessary for their existence. The people are not ungenerous, but they cannot be critical. The Astronomer is on his honour as it were, and this is nearly good enough, but not quite. If the Astronomer is a man of sufficient initiative and energy with a regulated imagination, he will not require much supervision, but he may feel that without the co-operation of his colleagues spread over the world his work may

* This question is discussed more closely in my paper on the Masses of Visual Double Stars read at this meeting.

be one-sided. He sees the need for organisation, and such organisation is not quite unknown, and has been found beneficial. Such occasional events as the transits of Venus and total eclipses of the Sun generally lead to some loose co-operation. More organised affairs were the Star Catalogue of the *Astronomische Gesellschaft* (a society having its headquarters in Germany, but with international aims). It divided the sky into zones, and allotted these to certain observatories, which were willing to co-operate. The catalogues actually published have been contributed by Austria, England, Holland, Germany, Norway, Sweden, Russia, and the United States. This organised effort, started in 1868, is still going on. The other and more important organisation is that of the *Carte du Ciel*, started in 1887, and in which our first President took a leading part—he was connected with it from its inception, and when he died he was the President of the Commission. The scheme for the variation of latitude observations is also an international organisation.

All these organisations were voluntary. In every way they were useful. The problem is whether we can extend the organisation to the whole body of Astronomers, and yet not destroy their initiative. A control, however light, which would destroy initiative would be fatal. At present many observatories furnish an annual report. Thus the Royal Astronomical Society in London publishes reports from most of the observatories in the Empire; the *Astronomische Gesellschaft* does the same for all the German, many Continental, and a few American observatories; the French Government publishes the annual reports of all French observatories. Other observatories furnish annual reports to their own governments or controlling bodies, and some of these are printed and circulated. Still other observatories, and these in no small number, publish no reports. The change I advocate is a very small one; it is that every observatory should furnish an annual report to its authority, and that these authorities should transmit the reports to an international association of astronomers, for comment and return. The report should be divided into sections somewhat as follows:—(1) Working staff of observing astronomers, non-observing astronomers comprising computors and ordinary assistants. (2) Detailed list of instruments, which cost over £250 a-piece. (3) How many Observers have permanent quarters in the grounds? How many non-observers have ditto? (4) Efficiency of those instruments in past years in percentage of hours available for work. (5) Observations secured in past year. (6) Observations published, being prepared for publication, etc. (7) Unpublished observations made in previous years—reason for non-publication? (8) Projected lines of work. (9) General notes and explanations.

All these reports should be examined and analysed by a committee of the international association and then published. The committee would then make its suggestions to the controlling bodies, leaving these to act on them or not. In this way the

careful minister or even the conscientious member of parliament could find out the opinions which an expert body holds concerning the institution for which he is asked to vote money. The advisory body could suggest to those astronomers who have sufficient equipment, but make no use of it, useful lines of research. The ardent astronomer who cannot persuade his government to provide funds would find himself in a stronger position when he has behind him an international body. The lethargic astronomer would find that his colleagues elsewhere look to him to do his share. Better than all, it might be possible to arrange that research students could visit and work at observatories whose equipment is not in full use. It would be invidious to give examples of observatories not working up to their potentialities—few can—but several make no attempt at any work, and have become little better than sinecures*—it must suffice to say that at least two of the observatories possessing exceptionally large refracting telescopes have not contributed one month's work from them in the last 20 years—their expensive equipment is idle and slowly deteriorating—the output from many others is disappointingly small. If some international association had the power to recommend that these great telescopes were put into commission, or better still, to assign research students to their use, it would be a good thing.

In ancient days princes and men of wealth founded religious institutions called abbeys and monasteries. They did so because they considered they were helping the cause of humanity—and for centuries these bodies did respond to a real need—but the need passed, and only effete institutions remained—ultimately to be swept away—and to-day princes and men of wealth do not found abbeys. In modern times—the most ancient observatory is not old—princes and men of wealth found observatories because they consider they are helping the cause of humanity. It is unnecessary to push the analogy. The ardent astronomer will not permit to to be pushed too far; he will organise with his colleagues for the advancement of his science, and the consequent enlargement of man's intellectual horizon.

I have only dealt with the organisation of a branch of Science somewhat widely detached from the current activities of the World. It would have been too ambitious to sketch the organisation of a state or of humanity at large. But such organisation must come. The War every day is showing us how necessary it is to organise for production—even if only in the munitions of war—and not for profit. We are living in dangerous times, times in which it behoves the man of Science, who is actuated by no selfish interests, to exert his power in remoulding the new society when the time, now near-at-hand, comes.†

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* They may provide a time or meteorological service of some local importance, but as institutions for research work of any kind their efforts are negligibly small. At least 33 per cent. of the Observatories listed in the Nautical Almanac publish nothing.

† The interpretation of the social structure by means of analogies drawn from the science of Biology appears especially promising.

The notable discussion in the House of Commons on the 13th May last (reprinted in *Nature* of the 20th May) on the motion of the Government to form an Advisory Council on Industrial Research, sets an example, which is sure to be followed by other British communities. All the debaters spoke of the extraordinary example of Germany rising to great material power through the spread of technical education and scientific research. No country can afford, or would be justified in lagging behind, but a more ethical objective should be the ideal.

In South Africa several problems have suggested themselves, but the experimental work would be very costly, and might, after all, be insufficient, so that their solutions do not appeal to private enterprise—the local production of liquid fuel is one of these problems—liquid fuel can be made both from low grade coals and from agricultural produce, and it is within the range of probability that what to-day are considered noxious weeds* might have an economic value in the production of alcohol. Again the extraordinarily favourable duration of sunshine in the Union invites the trial of sunpower boilers, especially for pumping. A census of the water power "white coal" is also desirable, because while we have no great spectacular falls of water excepting the Victoria Falls, we must remember that our high veld rivers have a descent of 6,000 feet to sea-level, and some of this fall is probably economically available.

If Science is co-ordinated knowledge, what is the Scientist? The true type of Scientist is a man of faith, believing in the power of co-ordinated knowledge to make the World a purer and a better one. If the object of Science was only the material conquest of Nature it would be unworthy, and sooner or later it would be rejected by mankind. The faith of the Scientist is unlimited—he might declare his creed in words somewhat as follows† :—

> I believe in the ultimate distinction between Good and Evil, and in a real Process in a real Time. I believe that it is my duty to increase Good and to diminish Evil. I believe in doing so I am serving the purpose of the World. This I know and I do not know anything else; I will not put questions to which I have no answer, and to which I believe no one has an answer. Organic Action is my creed. Abstract speculation weakens Action. I do not wish to speculate; I wish to act; I wish to live.

Or, he says, using the words of Bacon:—

> The knowledge of Truth, which is the Presence of it; and the Beleefe of Truth, which the Enioying of it; is the Soveraigne Good of Humane Nature. The first Creature of God, in the workes of the Dayes, was the Light of the Sense; The last, was the Light of Reason; And His Sabbath Worke, ever since, is the Illumination of His Spirit.

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* Such as the euphorbia and other cacti.

† Adapted from "Appearances,' by G. Lowes Dickinson (1914).

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President of the Section.—F. E. Kanthack, M.I.C.E., M.I.M.E.

MONDAY, JULY 5.

The President delivered the following address:—

The Section of which I have the honour of being President this year, embraces a somewhat curious mixture of pure and applied science, and it is difficult, in an address of this character, to find a common denominator. Sectional Presidents, as a general rule, confine their remarks to their own peculiar scientific compartment. As a civil engineer, I am perhaps fortunate in being intimately concerned, more or less, with all the science branches of this Section, and I have elected to address a few remarks to you to-day as an engineer in general, and not as an irrigation engineer in particular.

It is quite impossible this year to deflect one's mind from the appalling struggle which is now taking place. The great war, especially in Europe, differs from all previous conflicts, in that applied science is playing an overwhelmingly important part. Almost every branch of science has been drawn upon, and particularly those embraced in this Section. Mathematics, physics and engineering are the essence of gunnery. Engineering science and practice are drawn upon in every phase and branch of modern warfare. Irrigation, even, has played a very important rôle, as our enemy learned to their cost on the Yser Canal in Flanders. Architects have a very painful interest in the war. They, together with all lovers of what is beautiful, mourn the destruction of priceless gems of Gothic monuments.

There is, however, one factor in this war which is entirely novel, and has had more far-reaching effects than anything else, and that is the internal combustion engine.

The extraordinary rapid development of this particular form of prime mover has entirely revolutionised warfare. Though this type of engine was brought to a very high state of efficiency some years before the present war, and was adapted to serve all the needs it now serves, in no previous campaign has it taken up the dominating position which it now occupies. Briefly stated, the result of the invention and development of the internal combustion engine is mainly seen in motor transport and aviation, and it is quite unnecessary for me to enlarge on the far-reaching effects of these two factors in the present war.

The origin of the gas engine is imperfectly known. It certainly dates back to the latter part of the 17th century, and

quite a large number of inventors occupied themselves with this form of heat engine. It remained for Otto to overcome all difficulties and embody all the theories of his distinguished predecessors in a reliable and practical engine.

Otto and Langen's first engine—a free piston engine—was exhibited at Paris in 1857; but it was not until 1876 that Otto produced an engine which was the real precursor of all modern gas engines. Otto's work occupied 22 years, and is a record of extraordinary industry and perseverance. The successful engine of 1876 embodied the four-stroke cycle principle now universal in all automobile and aeroplane engines, and in most stationary gas and oil engines. This cycle had, however, been suggested by Beau de Rochas as far back as 1862, but the principle upon which it is based, the compression of the explosive charge in the cylinder, was in the minds of several engineers about that time,

The four-stroke, or Otto cycle, is so called because four strokes of the reciprocating piston in the cylinder are required to complete the series of operations. These are as follows:—

Firstly: The induction stroke, during which the explosive charge is drawn into the cylinder.

Secondly: The compression stroke, during which the charge is compressed into a small volume.

Thirdly: The explosive stroke, during which the gases are expanded.

Fourthly: The exhaust stroke, during which the products of combustion are expelled from the cylinder.

The development of the "Otto" gas engine proceeded steadily, mainly in the hands of British manufacturers, from 1880 onwards, the improvement being most marked during the last twenty years of the last century, and during this period of development the indicated thermal efficiency increased from about 16 per cent. to 37 per cent. This increase was mainly due to the steady advance in compression pressures adopted, which rose from approximately 30 pounds per square inch to over 200 pounds per square inch. All the earlier engines worked on ordinary town illuminating gas, but later on producer gas and waste gases from blast furnaces were largely used, more especially in engines of larger sizes, developing as much as 2,500 brake horse-power and over, but in all cases the very high thermal efficiency has been maintained.

The modern gas engine is, as regards thermal efficiency, greatly superior to the steam engine, and is consequently a much more economical prime mover. It has many other points in its favour, amongst which are rapid starting, less space occupied, and the small engines require less skilled attention than in the case of steam engines. The development of large engines working on blast furnace gas has had the most far-reaching effects in the iron and steel making industries, and is now utilising vast quantities of energy which, for generations, have been wasted.

Oil engines have developed more or less concurrently with gas engines, and are in principle the same. The oil engine in its general form is merely a gas engine with a special device for vaporising the oil fuel, which is then mixed with the requisite amount of air to form an explosive mixture. The term "oil engine" is usually applied to engines working on petroleum and heavier oils as distinct from engines working on light oils, such as benzine, naptha or petrol. The heavy oils are not readily volatilised, and require special vaporising devices. They are used almost wholly in stationary, agricultural and marine service, whereas the lighter ones, with a very low specific gravity and low flashing points, are very readily volatilised, and are eminently suitable as fuels in small high speed engines, familiar in motor-cars and aeroplanes.

The petrol engine, under which head may be included all internal combustion engines using highly volatile fuels, is essentially a small high speed motor, and the evolution of this engine from the larger slow speed Otto cycle gas engine stands mainly to the credit of Daimler. Up to the early eighties the speed of even the smallest combustion engines did not exceed 200 revolutions per minute, but Daimler, in 1883, produced an engine running upwards of 800 revolutions per minute. Daimler's achievement was mainly a mechanical one, and was embodied in the successful employment of very high speeds of rotation, which made it possible to greatly reduce the weight and bulk of the engine without sacrificing power. Daimler produced his first motor bicycle in 1886, and the first motor-car fitted with a Daimler engine was in 1887. In 1889 the famous firm of Panhard and Levasser undertook the manufacture of Daimler motors in France, and the subsequent evolution of the motor-car in that country was extraordinarily rapid. The early engines were low powered, with single and two cylinders, air cooled, and hot tube or battery ignition, yet the development of the modern high-powered engine, with four and six cylinders, water-cooled, and high tension magneto ignition, occupied only a few years.

It is impossible for the non-technical individual to realise and appreciate the enormous amount of scientific work and inventive genius which has been expended on the motor-car, and especially on the engine. New metallurgical processes had to be invented to produce steels of great strength able to survive the shocks and strain of hard running, while the various machine tools and manufacturing processes connected with motor-car construction are no less wonderful than is the finished article. The average modern motor-engine has a normal speed of from one to two thousand revolutions per minute, and it requires no technical mind to realise that thorough reliability under such working conditions requires a mechanism of supreme excellence. Yet this reliability is but a few years' old. Even ten years ago motoring was full of troubles; twenty years ago a motor trip was a most uncertain undertaking.

With engine reliability came its adaptation to need of aviation, and aviation practice developed a new species of motor engine, in which economy in petrol and oil consumption was, to a considerable extent, sacrificed to minimise weight per horse-power and extreme reliability. As regards the weight per horse-power, the first stationary petrol engines made in the year 1880 weighed about 1,110 lbs. per horse-power. Six years later Daimler, in his early motors, had reduced this weight to 88 lbs. per horse-power, and during the evolution of the motor engine this figure was rapidly reduced. In modern motor-car engines the engine weight, including the heavy fly-wheel, ranges from 18 to 24 lbs. per nominal brake horse power.

In aeroplane motors the weight has been cut down to a wonderful degree, and engine weights per rated B.H.P. are given as varying from 21 lbs. to 1.8 lbs. This last figure is claimed for the 14-cylinder, 123 H.P. rotary Gnome engine. In the 7-cylinder Gnome engine the weight is only 3½ lbs., and 5 to 6 lbs. per rated H.P. is comparatively common in good engines.

Another type of internal combustion engine of comparatively recent origin is the Diesel engine. This engine works on what is known as the continuous or slow combustion principle, whereas all gas engines, petrol engines, etc., work by explosion, that is to say, by combustion at approximately constant volume. From the point of view of thermal efficiency, an engine on the slow combustion principle is more efficient than one working on the explosion principle. The slow combustion principle was first used by Brayton in America in 1872, but it was not until 1893 that the late Dr. Diesel published his ideals defining the proper principles on which a heat engine should be designed in order to ensure its working with a maximum economy. Diesel's ideas were embodied in a patent taken out in 1892, and the manufacture was taken up by two important engineering firms in Germany, and the highly successful modern Diesel engine stands to the credit of the Germans—Augsberg engineering firm.

The principle of this engine is to produce the highest temperature of the cycle before combustion of the charge takes place, and this high temperature is obtained solely by the compression of air, which is effected in a separate air compressor, and not, as in the usual four-stroke cycle, by a compression stroke of the piston. The initial compression of the air is very great, reaching as high as 500 lbs. per square inch. At the commencement of the expansion stroke liquid oil fuel is injected into the charge of compressed and highly-heated air, and combustion of the mixture immediately takes place at more or less constant temperature.

This engine immediately showed itself to be the most economical internal combustion so far as fuel consumption was concerned, and it was adapted to use low grade heavy oil fuels, such as crude petroleum and heavy vegetable oils, which could not be used in other types of internal combustion engines. This

type of engine has proved a great success for certain classes of work, and in the short time since it was placed on the market several millions of brake horse-power have been built.

In recent years an intermediate type of engine has been produced, and has become popular, known as the semi-Diesel engine, which combines to some extent the merits of the high compression system of the Diesel engine and those of the low compression oil engine.

This very briefly covers the range of internal combustion engines, which are found in everyday use. All are of the reciprocating type, but there is a possibility that a gas turbine may yet emerge from the experimental stage and take practical shape.

It has been shown that the internal combustion engine has in a very short space of time developed in many directions. In the course of its evolution many difficulties have been encountered. Some of these have been wholly surmounted, others have only been partially overcome. Progress in some directions has been very rapid; in others slow. Thus, in the case of small power units up to four to five hundred horse-power, very rapid development has taken place, and a very high degree of perfection has been attained, but with large power units many difficulties, anticipated and otherwise, have not been fully overcome.

Improvement in thermal efficiency has been very rapid. The average effective indicated thermal efficiency of gas engines is about 35 per cent. Theoretically, it is possible to further increase this efficiency by increasing the compression ratio, but practical considerations place a limit on such an increase, and one of the best authorities of gas engines considers it unlikely that a 40 per cent. thermal efficiency will be exceeded in commercial practice. So far as economy of heat is concerned, both gas and oil engines have considerably surpassed the best steam engines, and within certain prescribed limits the internal combustion engine now entirely holds the field against its older rival, the steam engine.

In the case of larger units, more especially blast furnace gas engines, the most recent improvement, as regards thermal efficiency, consists in using the heat contained in the exhaust gases of the gas engine for raising steam, and at a lecture recently delivered by Professor Hubert, of Liége University, before the Iron and Steel Institute in London, a large experimental plant, installed by the Cockerill Company at Seraing, in Belgium, is described. In this plant the exhaust heat from four gas engines developing an aggregate of 5,000 B.H.P. is utilised, and it is stated that 55 per cent. of the heat of the waste exhaust gases is removed by the boilers, thus increasing the thermal efficiency of the gas engines by about 13 per cent.

In the matter of fuel, the internal combustion engine secures a very distinct advantage. The steam engine is dependent upon a fuel by means of which water can be economically transformed into steam in a boiler and furnace. In the best types of steam plant about one pound of the best Welsh steam coal is required

to develop one indicated horse-power in the engine. A good suction gas engine and generator working with best Welsh anthracite will equal and improve upon this performance. At the same time gas engines are working on town gas—obviating the complication, space and mess involved in a boiler plant, or gas may be produced in a generator from almost any fuel or refuse which can be made to burn. Or, again, the waste gases of the blast furnace may be used. Engines using town gas are an obvious convenience to users of small powers in urban areas where gas mains are installed. The engine working with its own gas generator, more especially the suction gas engine, has made power available to thousands of users who could otherwise only obtain power at a high, or even prohibitive, cost. Many power users in South Africa have scrapped a steam plant, installed a larger suction gas plant, and have paid for the latter out of one, or, at the most, two years' saving in running costs.

The enormous engines installed at up-to-date iron or steel works, and working on waste blast furnace gas, save these works great sums of money annually, which were formerly spent on coal. To give an example of one of these large installations, at the works of the Indiana Steel Company, there are in one power house 17 sets of large Nurenberg type engines, each developing 2,500 kilowatts, or 3,000 B.H.P.; 51,000 B.H.P. in all. Both on the continent of Europe and in the United States there are many large blast furnace gas engines developing over 5,000 B.H.P. for each unit.

Coming to the oil engines, these equal the gas engines for efficiency, but their great merit lies in the convenient form of fuel. A pint of oil per B.H.P. hour represents but little bulk, and oil engines are consequently larger in use as portable machines or tractors for agricultural and other purposes.

All the smaller gas and oil engines are very easy to manage, and require no regular expert attention, and can all be started up from cold within a few minutes—the least characteristic is of enormous advantage to the small power user. The small high-speed engine working on petrol or alcohol falls into a separate class. The thermal efficiency of these engines falls considerably short of that obtained in gas engines, and rarely exceeds 25 per cent. when working at fairly high speeds, but the value of these engines lies in other directions.

The extraordinarily small weight of these engines per horse power, the high speed of rotation, ease and speed with which they can be started, the small bulk of the fuel supply and its convenience, have endowed these motors with an importance hardly realised by most people. Modern automobilism and aviation, and all that these terms stand for, are the direct result of the development of this type of engine by Daimler. Daimler produced the first motor bicycle and the first successful motor-car. Besides, Daimler, Benz deserves a considerable amount of credit as a pioneer in the production of an internal combustion

engine suitable for self-propelled road vehicles. It is difficult omnibus, and the motor bicycle, are derived from the curious to believe that the motor-car, commercial motor lorry, motor looking vehicles built during the late eighties. Early specimens, dating back to 1890, have found their way into the National Museum at South Kensington. In the large towns of Europe, horse-drawn vehicles are rapidly disappearing from the streets, and the self-propelled motor vehicle has, within the past ten years, revolutionised the traffic conditions in London and other great cities.

With regard to aeroplanes and dirigible balloons, these owe their existence and success wholly to the internal combustion motors. The modern flying machine—certainly the monoplane—is, in its essentials, very little different from the model made by Henson about 1840. He invented it in 1835, and filed his patent specification in 1842. The model was built in accordance with data given by Sir George Cayley, who made a profound study of flight about a century ago. Cayley forecasted the aeroplane, and most of its essential features. Henson's monoplane was a steam-driven machine, but in his day no satisfactory motor was available, and sixty years had to elapse before the petrol engine provided a sufficiently light, powerful, and reliable motor to make the aeroplane a success.

What the steam engine was to the nineteenth century, the internal combustion engine is to the twentieth, and the effect of the latter on society is probably greater and more far-reaching than was the case with the steam engine. The effect of the petrol motor in the great world's struggle now raging is so great that I desire to call attention to the rapid evolution of this type of prime mover. Little did Otto and the earlier pioneers realise the colossal consequences which their work would have, not alone in the interests of civilisation, but as a powerful aid to the greatest orgie of destruction in which mankind has ever taken part. Nevertheless, the development of the internal combustion engine is probably the greatest engineering achievement which the world has yet witnessed.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President of the Section.—H. Kynaston, M.A., F.G.S.

TUESDAY, JULY 6.

The Section having assembled, Mr. R. T. A. Innes, F.R.A.S., F.R.S.E., President of the Association, expressed his sense of the loss that had befallen the Section and the whole Association in the decease of the President of the Section a week ago. He moved that the Section express its condolence with the bereaved family of the late Mr. Kynaston.

The motion was agreed to in silence by a standing vote.

Professor D. F. du Toit Malherbe, M.A., Ph.D., Secretary of the Section, then read the following address, which had been prepared for delivery by the late President:—

RADIO-ACTIVITY IN ITS BEARING ON GEOLOGICAL PROBLEMS.

During recent years an entirely new and novel branch of chemistry has sprung up—one might almost say, an entirely new science. The discovery of Radium and Radio-activity, involving the remarkable phenomenon of atomic disintegration and the consequent spontaneous liberation of energy in the form of heat, has not only profoundly affected Chemistry and Physics in opening up some of the most fundamental questions concerning the ultimate constitution of matter, but it has given the geologist good reason to pause, and he cannot help seeing that the study of Radio-activity is bound to considerably modify his outlook upon various terrestrial problems. It has put things in a new light, and in this new light they have been re-considered, and are still presumably undergoing treatment by authorities such as Professors Strutt, Joly, Holmes, Chamberlin, and others, and it is the duty of every geologist to fall in with the new line of thought, at least as far as it affects his particular science.

The whole subject, however, although still quite a young one, is far too large and intricate to be gone into in detail here. I do not propose to go into the chemical side of the subject—that can safely be left to the Chemists themselves—but I would like to point out briefly the very important bearing which the phenomena of radio-activity have upon various important geological questions.

The old problems of the internal heat of the earth, and the condition and the constitution of its interior, have to be considered afresh in the light of radio-activity. The present imperfection, however, of our knowledge of the distribution of radium

and radio-active substances in the earth as a whole is a handicap in this task. It will therefore be of interest first of all to review briefly what is known of this branch of the subject.

Radio-active matter in the form of compounds is now known to be widely distributed over the face of the globe, a distribution which has, no doubt, been considerably influenced by the surface changes which the Earth has undergone. It is found in minute quantities in practically all the rocks of the Earth's surface, in nearly all the waters and in the atmosphere, while hand in hand with a general tendency to diffusion there has also been, as we shall see, certain tendencies to concentration.

So far as the crust of the Earth is concerned, the igneous rocks may be taken as the source of the radio-active substances. They have a higher radium content than the sedimentary rocks, since the latter have been derived from the former, and in the processes of denudation and deposition a certain amount of the radio-active contents of the igneous rocks is taken up by the atmosphere and the waters. With regard to the igneous rocks Professor Strutt has found a higher radium content in the acid than in the basic rocks, and from the number of analyses so far completed, estimating the radium content in billionths of a gramme per gramme of rock, we get the further interesting generalisation that a combination of silica with a high proportion of alkali, such as is found in the phonolites and rocks of a similar class, favours the relative abundance of radium in the igneous rocks. The extent to which the alkalis are present is, apparently, according to the later results of Holmes, the predominating factor in determinating the quantity of radium present.

Joly's results indicate the probability also that volcanic and, to a less extent, hyperbyssal rocks on the average have a higher radium content than their plutonic equivalents. This may be accounted for by the fact, demonstrated by numerous analyses, that volcanic rocks contain, as a rule, more soda and more silica than the corresponding plutonic rocks.

Radium, therefore, shows a marked preference for alkaline and acid rocks, and also for volcanic rocks as compared with plutonic. Apparently, therefore, the processes of differentiation responsible for such rocks have also been favourable for the concentration of uranium, and consequently of radium. The same may also be said of thorium, as indicated by the association of uranium and thorium-bearing minerals with pegmatites genetically related to granites and syenites of an alkaline character. Besides pegmatites, radio-active matter also tends to be concentrated in certain rock constituents, such as zircon, pyromorphite, apatite, etc.

These results regarding the concentration of radio-active compounds are certainly significant, but the data are, perhaps, as yet hardly sufficient to enable us to draw any final conclusion from them. The close association with acid pegmatites, however, suggests that the same process of differentiation may have

been in operation in the case of the radio-active elements as has also been responsible for the selective concentration of the various minerals so characteristic of the final activities of an igneous magma, and frequently characteristic of pegmatites, such as tourmaline, topaz, zircon, beryl, cassiterite, etc. It is considered by Holmes in this connection that the action of magmatic gases and vapours has largely controlled the process of differentiation, which has resulted in the extraction of the radio-active elements and their concentration in the subsidiary portions of the magma, such as the pegmatite veins.

Chamberlin considers that since in the radio-active elements we have a thermal agency of very high efficiency, it is probable that, in virtue of the heat-producing activities of these elements, arising from continuous atomic disintegration, they have had a decided influence upon the production of igneous intrusion and extrusion. In his opinion, they thus assist by their action other agencies such as compression, not only in the liquefaction of rock matter, but also in facilitating a passage for it towards the surface. In short, the peculiar activities of the radio-active elements have been one of the principal agents in effecting their concentration towards the surface of the earth.

Leaving out of consideration, however, the actual methods of distribution and concentration, let us return to the relation between radio-activity and the earth's internal temperature. We have seen that radium is widely distributed over the more superficial portions of the earth. If, then, radio-active matter was distributed in a similar proportion throughout the entire mass of the earth, from the surface to the centre, it has been estimated that the observed temperature gradient as the earth is penetrated, would be very much higher than it is; in fact, the earth would never have become fit for habitation, and would actually be growing hotter! But as this is not the case, we can only conclude *either* that radio-active elements are absent from the more central portion of the earth, or possibly present to a quite inappreciable extent, *or* that, if there is in the earth an equable distribution of radio-active matter in depth, then there must be some agency, such as pressure, which is able to restrain its activity in depth or altogether prevent its atomic disintegration.

The results of various observations, deductions, and experiments, however, tend very clearly to show that radio-active substances can, apparently, undergo disintegration persistently and uniformly under all known terrestrial conditions, and so their action is probably not controlled or influenced in any way by pressure or temperature. These considerations certainly point to the conclusion that the radio-active elements are practically confined in their occurrence to the crustal portion of the globe. The evidence of concentration that I have already referred to tends to support this view, although the very fact that concentration and diffusion has, and no doubt still is, taking

place would naturally lead us to suppose that at one time they had a more uniform distribution.

Professor Strutt concludes that a distribution of radium, equal to that observed in the surface rocks, down to a depth of 45 miles, would supply sufficient heat to account for the observed temperature gradient of the crust of the earth, while Joly's estimate for the thickness of the radio-active crust is approximately 20 miles. These views, however, apparently take no account of heat derived from other sources such as movements within the crust, chemical changes, etc.; nor of loss of heat by volcanic action. As further supporting the idea of the great influence of radio-activity on the internal temperature of the crust, it is of interest to note that Joly's investigation into the radio-activity of the Simplon and St. Gothard rocks brought out a remarkable correspondence between the estimated radium content and the observed temperature gradient, the higher gradient corresponding with the higher radium content, whereas in the case of the lower gradient the rocks examined showed a decided fall in the amount of radium present.

Let us now see whether the more generally accepted views as to the constitution of the inner earth support the idea of a comparatively thin radio-active crust or not. Although there are some who hold contrary opinions, it is certainly widely accepted that the earth is solid throughout, and consists of a dense metallic core probably approximating in composition to that of the heavier class of meteorites, which consist almost entirely of nickel-iron, surrounded by more stoney material, showing, on the whole, a gradual decrease in density towards an outer crust. The arguments from specific gravity and pressure support this view, and the more recent hypothesis of Chamberlin as to the origin of the earth involves the building up of an essentially solid globe, this being effected, according to his view, by gradual aggregation and accretion from minute bodies, or planetesimals, constituting portions of a spiral nebula.

The results so far obtained by various workers from investigations into the phenomena of earthquake waves unfortunately differ somewhat amongst themselves. But, in any case, they demonstrate that the interior of the earth is very much denser and more rigid than the crust, owing to the much higher velocity at which the earthquake waves travel through it than through the material forming the crust. Professor Milne has calculated that the change in velocity due to change in the condition of the interior commences at a depth of about 30 miles. R. D. Oldham also found a marked difference between the crust and the interior, but he divides the interior into two zones, the inner being of unknown composition owing to a *decrease* that he claims to have observed in the velocity of certain of the waves as they traverse the central core. Further, from the results of recent observations carried out in Germany, it is concluded that beneath the outer crust there are four zones, the innermost

having a density (of 7.8 to 8), approximately equal to that of metallic iron.

The evidence from earthquakes, therefore, though not altogether conclusive as to the structure of the internal portion of the earth, is certainly consistent with the conclusion arrived at from the study of radio-activity, of a relatively thin superficial crust, differing essentially in composition from the interior, and probably varying in thickness in different parts of the globe.

It will be interesting now to inquire how far the facts observed concerning meteorites bear upon the structure and composition of the earth and the idea of a radio-active crust. First of all a few words as to their nature and origin.

Meteorites are peculiar solid bodies which are continually entering the earth's atmosphere from outer space, and occasionally reach its surface. There are two principal kinds, metallic and stony, and between these there is every gradation, and altogether four fairly distinct classes can be recognised according to the relative amount of metallic and stony matter present. These are:—

1. *Holosiderites*, consisting almost entirely of a coarsely crystalline alloy of nickel and iron.
2. *Lithosiderites*, consisting of a nickel-iron matrix, enclosing granules of basic silicates, such as olivine and bronzite.
3. When the nickel-iron occurs in grains embedded in a matrix of the silicate minerals, they are called *Siderolites*.
4. The *Stony Meteorites*, which are divided into *Chondrites* and *Achondrites*, according to the presence or absence of peculiar more or less rounded grains of Olivine or Pyroxene, known as *Chondri* or *Chondrules*.

In addition to the above, there is a remarkable group of bodies, which are supposed by Suess and other authorities to be of extra-terrestrial origin, and therefore, are regarded by them as meteorites. These are called *Tektites*, and consist of peculiar button-shaped masses of glass, and have been found in Bohemia and Australia. If these are to be included among the meteorites, they are exceptional, as they contain 80 per cent. of silica, whereas the stony meteorites do not contain more than 40 per cent. Others assign a terrestrial volcanic origin to these bodies, but the possibility of their belonging to the meteorites should be borne in mind.

From the fragmentary nature of most meteorites, it is evident that they are merely fragments of larger bodies. In some of their characters they resemble terrestrial rocks, while in others they show striking differences from them,—thus many of the iron meteorites closely resemble the native iron occurring in the Greenland basalts.

On the whole, nickel-iron is apparently more abundant in meteorites than stony material, the metallic meteorites are usually

the larger of the two kinds, and occasionally have fallen in large masses weighing several tons. The stony meteorites are smaller, and probably fall more frequently, but are naturally more likely to be missed than the others, and more likely to become decomposed and disintegrated after their fall—and so lost. The meteorites actually known probably, therefore, do not give us an accurate idea of their average composition. If this were known it would doubtless be found to show a somewhat lower proportion of iron than has commonly been supposed to be present, and, at the same time, it would give us the average composition of the body or bodies from which the meteorites have been derived.

Various theories have been advanced as to their origin, but that which best fits with their characteristic features is that they owe their origin to the disruption and fragmentation of some small atmosphereless body or bodies in space, resembling the satellites or asteroids. They now constitute fragmentary masses, which travel in space in an erratic manner, and with a high velocity which has been estimated in some cases to be as much as 40 or 50 miles per second.

The meteors which exist as swarms and appear as showers of so-called "shooting stars" at definite times, such as the August and November meteors, are apparently of a different class, as they follow definite orbits about the Sun, and appear to be closely connected in some way with comets, and do not usually reach the Earth. It is quite probable, however, that in composition they closely resemble the iron and stony meteorites.

A brecciated structure is very common in many meteorites, and occasionally these contain fractured chondri among the included fragments. As chondri are structures known only in meteorites, this implies that fracturing or brecciation and re-cementation took place in the parent body; larger chondri also sometimes enclose fragments of smaller ones. Slickensided surfaces and veins are also sometimes present in meteorites, which implies movements and fracturing in the parent body.

The very coarse crystallisation of the nickel-iron meteorites indicate that their substance cooled slowly under a high temperature and pressure as might be expected to be present in the inner portion of the body from which they were derived. Also the crystal form of the nickel-iron is usually *octahedral*, which indicates that the metal must have been heated to a temperature of, at least, 860° C. before cooling. The occurrence of diamonds, which has been proved in two cases, also indicates a high pressure.

Many of the stony meteorites contain a considerable proportion of glassy matter; this implies rapid cooling, such as would take place at the surface of the parent body, and is analogous to the formation of glass from rapid cooling in terrestrial lavas.

Certain meteorites contain hydrocarbons—compounds resembling terrestrial bitumens or petroleum. These are volatile and combustible substances, and their presence shows that such meteorites could not have been subjected to great heat subsequent to the formation of the hydrocarbons, and that the heating, as the pass through the earth atmosphere, has been only superficial. All meteorites contain included gases, such as hydrogen, carbon monoxide, carbon dioxide, marsh-gas, and sometimes nitrogen. Terrestrial igneous rocks can also be made to give off similar gases.

In contrast to the average rocks of the Earth's crust, meteorites show an excess of iron, nickel, and magnesium, and what is especially noteworthy an almost entire absence of water, free oxygen, and free silica. The more important rock-forming minerals of the earth's crust are absent, such as quartz, orthoclase, the acid plagioclases, micas, and amphiboles, the chief minerals of the meteorites being present only in small proportion in the crust. The crust rocks of the earth abound in free silica, lime, alumina, and alkalies, while meteorites abound in iron, nickel, and magnesia. The minerals of meteorites are always unaltered, and show no signs of weathering; there are no hydrated minerals, and there are no minerals present (such as the zeolites, epidote, tourmaline, etc.), in the formation of which water or water-vapour takes part.

These facts point to the conclusion that the parent body from which meteorites were derived had no water nor an oxygen-bearing atmosphere, having probably been too small to retain their gases in a free state. In this case there could have been no selective weathering of its materials, and no mineralogical differentiation of the terrestrial type, and therefore no formation of the terrestrial type of crust. The atmosphere and water of the earth have been largely instrumental in the formation of its particular kind of crust, and the free silica of the earth's crust is easily accounted for by the working over and over of its original constituent materials by their agencies. By the exposure of the silicates to carbon dioxide the bases are changed to carbonates, and silica is set free.

Most of the above facts regarding meteorites and what they imply have been pointed out by Farrington and others in their studies of the structure and composition of meteorites, and Farrington also concludes from their structure, that the material of the parent body was arranged according to density, and had cooled from a liquid or semi-liquid state before disruption.

Finally, Chamberlin further considers that the meteorites of the erratic type are merely the incidental products of stellar systems, and that the meteoritic condition does not seem to represent a generative method whereby stellar systems are evolved.

It is not unreasonable to suppose from the characters of meteorites, and in view of the known uniformity of matter in

space, that the constitution of the meteoritic parent body might show us to some extent the constitution also of the earth. We cannot, of course, say that the two would be identical in composition, but, at the same time, the strong analogy between meteoritic and terrestrial materials cannot be denied.

Thus, Suess, arguing from the chemical characters of meteorites and their relation to those of terrestrial ultra-basic rocks, has suggested that the earth consists of three principal zones—

1. A metallic barysphere, rich in iron and nickel.
2. An intermediate zone, rich in magnesia and silica; and
3. An outer crust, rich in silica and alumina.

Holmes supposes that there is a terrestrial zone corresponding in order of density to each of the principal types of meteorite. Daly, in his recent work on the igneous rocks and their origin, also advocates a coarse stratification or zonal arrangement of the materials of the earth according to their density.

With regard to the radio-active characters of meteorites, we have so far very scanty information. The results, however, of Holmes' analyses show an absence of radium in the iron-meteorites, which, in view of the analogy between meteoritic and terrestrial material, strongly supports the conclusion of the absence of radium and, therefore, of uranium from the metallic core of the earth. The stoney meteorites showed, on the whole, a radium content rather less than that of terrestrial ultra-basic rocks, while a considerably lower amount appears in the iron-stone class, the radio-active matter occurring in very minute quantity in the silicate minerals. In the meteorite parent body, then, evidently, the radium content decreased with depth until it died out altogether, and showed, to some extent, a similar general type of distribution to that which we have seen apparently obtains in the earth. The inference is that radio-activity, and, therefore, the amount of radio-active materials tends to increase towards the surface of such bodies, and would show a progressive decrease with increase of depth, and of density of the constituent materials.

On the whole, the evidence from meteorites certainly lends support to the conclusion that the radio-active elements in the earth are concentrated towards the upper part of the crust. The concentration on the earth, however, is of a more advanced order, having been probably to a great extent controlled by selective mineralogical differentiation assisted by aqueous and atmospheric agencies, which we have seen were apparently absent on the meteoritic parent body, so that it may be supposed to have proceeded *pari passu* with the evolution of the more acid or siliceous rocks.

The problem of geological time is another of the questions which is being reconsidered in the light of radio-activity. In

the minerals in which uranium and thorium occur, radio-active changes have been going on continuously for vast periods of time. Hence, we should expect to find in these minerals the ultimate products of the atomic changes which have taken place, and the older the geological formation to which the mineral belongs, the greater ought to be the quantity of the products. It was found that these minerals contained the gas helium, and it is known that helium is one of the products of radio-active substances, and is being evolved by them at an uniform rate. If, then, calculations could be made of the amount of the stored-up helium, and of the elements giving rise to it, from these data the age of the minerals containing the radio-elements might be estimated.

There is always the probability, however, that the helium may escape from the containing mineral, which would naturally invalidate any estimate of this kind.

A variation of the above method has been applied to the pleochroic halos surrounding minute grains of radio-active minerals, occurring in the mica of certain granites, the halo having been caused by the action of the helium produced.

Lead is also supposed to be a product of the disintegration of uranium and thorium, and various estimates have been made on this basis as to the geological age of minerals of different geological periods, containing uranium and associated with lead.

The ages assigned to geological periods by Strutt and others by these methods are considerably greater than those arrived at by other methods such as that from measuring the thickness of the sediments and their rate of deposition, and amount to several hundreds of millions of years for some of the earlier geological systems.

The whole subject, however, is exceedingly complicated, and the present state of our knowledge of the exact nature and results of radio-active changes is hardly sufficient to justify thorough reliance on these methods as yet for estimating the age of the earth; though as chemical and geological investigations progress side by side, the radio-active method may become an important line of research.

The whole study of radio-activity in its bearing on geology has, I am sure, a great future before it, and in opening up to our knowledge such vast and unexpected stores of energy within the earth's crust, it gives a new significance to many problems, such as volcanic action, magmatic movements, and differentiation, and to the whole history and evolution of the earth, and of the structure and condition of its interior and of its crust.

Section C.—BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE, FORESTRY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

President of the Section: C. P. Lounsbury, B.Sc., F.E.S.

WEDNESDAY, JULY 7.

In the unavoidable absence from South Africa of the President, the following address, prepared by him for delivery, was read by Mr. C. K. Brain:—

SOME PHASES OF THE LOCUST PROBLEM.

Before proceeding to the subject of my address, I feel that an explanation and an apology for my personal absence are due to the members attending Section C. When the Council of the Association was pleased in March to offer me the presidency of the Section for the current session, I quite expected to be able to fulfil the functions of the office, and, sensible of the honour conferred on me, I gratefully accepted. It was not until some weeks later that I found it would be impracticable for me to attend the session; but when I sought to withdraw from the presidency, your secretary was good enough to ask me to retain the position and to leave my address to be read in my name. I sincerely regret having to miss the pleasure of being with you.

A presidential address is generally supposed, I believe, to give a review of the progress made in the arts and sciences encompassed by the section; and in following the lead of some of my predecessors in departing from this time-honoured custom, I crave the indulgence of the meeting. So many and so varied are the subjects covered by Section C, that only a man with enclycopædic knowledge could hope even to touch upon all of them satisfactorily. Keenly conscious of my limitations, I have chosen to address you on locusts, a subject that, I think, has the merit of general interest in this country. After all, I think I could show you that locusts, to some degree, concern all of the eight sciences comprised in the section. A connection with bacteriology, for instance, is evident inasmuch as the use of bacterial diseases for the decimation of locusts has been widely advocated; cultures of one organism (*Coccobacillus acridiorum d'Herelle*) for the purpose are now obtainable at the Pasteur Institute in Paris. Any link with sanitary science is less apparent, but now and again our town engineers are called upon to guard reservoirs and streams against pollution by the insects, and the time has been even at Cape Town when decaying myriads of locusts have been thrown back by the sea greatly to the distress of the dwellers in the mother city of our Association.

In selecting locusts as my subject, I am influenced by somewhat selfish official considerations. In my estimation, there is reason to believe that the Union is entering upon a cycle of years when swarms of locusts will be widespread and destructive; and by drawing your attention to these insects, I hope observations may be prompted that will help to elucidate the mysteries now surrounding the origin, development, decline and absence of locust eruptions. Not until the entomologist knows the causes underlying these phenomena will he be in a satisfactory position to recognize and interpret aright the happenings that portend a change from one condition to another. Within a few months locusts have appeared in small numbers here and there all the way from Basutoland on the east to Namaqualand on the west, and some have been observed as far north as Francistown in Southern Rhodesia, and as far south as Cradock in the Cape Province. Because the occurrence has followed close on a general drought, and after an interval of locust absence, it is conjectured that a new locust cycle is impending or, rather, has begun; and, in consequence, the Government is making expensive and troublesome preparations to fight the pest at a time when the condition of the public treasury renders strict economy essential. But as I shall undertake to show it is not really known for certain that severe and general devastation by the pest is threatened. It may be that there will be fewer locusts in the 1015-16 season than there were in the 1914-15 one. The advisers of the Government, the entomologists, owing to the present imperfect state of knowledge respecting the causes of locust abundance, may not be reading nature's signs as they should be read, or may be overlooking important indications. Therefore, public funds may be needlessly expended, and the people of the country needlessly agitated. On the other hand, far greater trouble than is now imagined may be imminent, and thus the Government's preparations prove inadequate.

The term "locust" is somewhat vague in its application to insects. I here use it to refer only to naturally gregarious, short-horned, so-called grasshoppers that are capable of long-sustained flight. Such insects are found on all the great continents, and by causing famines for man and beast, they have attracted attention from time immemorial. Chinese records of famines due to their depredations extend back over 2,000 years, and old Roman writers refer to parts of Italy being laid waste before the Christian era, while Biblical references will recur to you. At the present time great trouble with them is experienced in certain provinces of Russia and in Argentina. That Europe is involved may surprise some of you; but most of Europe south of the Baltic has been repeatedly ravaged, and in one great irruption in the middle of the eighteenth century the pest reached the British Isles, penetrating into Scotland and Wales, and being especially destructive in the midland counties of England. The invasions into Western Europe have always been from the East.

and their infrequency in the last hundred years is not improbably due to the country in the path the swarms would follow having been brought more and more under cultivation.

Locusts were observed in Table Valley by visiting mariners long before the settlement of Cape Town by the Dutch, and Van Riebeek experienced losses by them during his first summer in this country, 1653. A quarter of a century later, 1687, they again ravaged the gardens of the little colony, as recorded by Theal in his "History of South Africa." Apparently there was more trouble with the insects a few years later, but Theal observes that from 1695 until the closing days of 1746 the colony was free from them. On the 28th of December, he then records,

> They found their way in such vast numbers into Table Valley that the air seemed filled with them, and in few days there was nothing edible left, not even leaves on the trees.

The devastation in the surrounding country was equally severe, and the price of meat in the little colony doubled because so many cattle and sheep perished from starvation. History further records that the Cape authorities at the time were having a mole, or breakwater, constructed for the protection of shipping. The work was suspended owing to the fall in revenue and the increase in costs brought about by the locusts, and it may be added that it was never resumed. The name "Mouille Point"—that is, "Mole Point"—however, has survived for the place where the start was made. In February, 1843—that is, nearly a hundred years later—the Cape and surrounding districts were again visited by locusts. Crops, vineyards, and pasturages were greatly damaged, but, as it came later in the season, the damage was not so serious as on the previous occasion. Enormous numbers of the insects were blown into the sea and afterwards washed up. Mr. H. C. V. Leibbrandt, late Keeper of the Cape Archives, told me ten years ago that he clearly remembered the incident. The locusts, he said, lay nine inches deep along the beach at Sea Point, and created an intolerable stench. I make special mention of these visitations to indicate that the south-western districts of the Cape Province are not entirely safe from a scourge of locusts, and that the residents in that comparatively thickly-settled part of the Union should feel it to their interests to grant the Government help to combat the pest when it ravages other parts of the country.

Inland parts of South Africa are frequently devastated by locusts. One cycle of their abundance appears to have begun about 1797, eleven years after Graaff-Reinet, the first Karroo town, was founded, and to have continued until 1808. In 1824 the country, from the most northern settlements south to Bedford, was overrun, and the plague lasted until about 1831. The period 1842 to 1854 seems to mark their next invasion, and that from 1862 to 1876 the one following. Then for fourteen years

the country generally is reputed to have been free from them, but there are references to some occurrences in north central districts of the Cape Province during this interval. In 1890 they again appeared, and in the succeeding years—the country being more settled further inland—their depredations were greater than in any previous cycle. From 1890 onward they have been reported from somewhere or other within the confines of the Union every year, but I think the cycle, or series of cycles, may be considered to have ended in 1909. It seems probable that, for several years previous to the present year, locusts have been really as scarce as in any period since the settlement of the country. The railway, the telegraph, and the newspaper and agricultural publications now serve to bring to public notice, and to place on permanent record, occurrences that half a century ago would have excited only local attention, and have nowhere been recorded in print.

The locusts that ravage South Africa are of two very distinct species—the Brown Locust, *Locusta pardalina* (also called the Old, Small, Yellow and Khaki Locust, and often referred to *Pachytylus sulcicollis* and *P. capensis*) and the Red Locust, *Cyrtocanthacris septemfasciata* (also called the New, Large, Coast, Red-winged, Purple-winged, and Egyptian Locust, and referred to *Schistocerca* or *Acridium purpuriferum*). So far as known to me with certainty, no other true migratory locusts occur in South Africa. However, specimens of swarm locusts of the Brown type caught in the country have been referred to *Locusta danica* (*P. cinerascens*) and of the Red type to *C. internexa;* and in the South African Museum are Namaqualand specimens labelled *Acridium peregrinum*. The last-named insect and *L. danica* are North African locusts. The mature Brown, and much more so the mature Red locust, varies in colour and markings with age, and the Brown locust sometimes has greenish markings that give it an altogether strange appearance. It is not my purpose, however, to describe the insects. I merely wish to make it clear that, so far as my knowledge goes, at present there are two species, and two only; but I shall add that the simplest character by which the two may be distinguished is by the presence or absence of a prosternal spine. The group to which the Red Locust belongs has the spine; that of which the Brown is a member lacks it. It is very distinct in the Red Locust, a thorn-like projection on the underside of the neck.

The Brown Locust is congeneric with the migratory locusts of Europe and Asia, and is the commoner of the two South African species. It is pre-eminently an inland species, partial to grassy plains, and is the locust of the several cycles of which I have spoken. Sometimes it has migrated to the sea coast between Algoa Bay and the Kei River mouth, but I do not know that it ever reaches the Atlantic coast within the Union, or penetrates to the sea west of Cape St. Francis. At long

intervals it gets as far south-west as the Ceres district, and about 1898 a small swarm flew into the Hex River Valley above De Doorns, but in general the western Karroo seems too barren for its welfare, and it rarely crosses to the fertile coastal districts. The Kalahari Desert seems to be the starting place of great swarms that overrun German South-West Africa on the west, Rhodesia and the Transvaal on the east, and the Cape and Orange Free State Provinces on south and south-east.

The Red Locust is congeneric with the large North African locust, and also with the locust of Argentina. In Natal and the Cape Province, it is essentially a coast-frequenting insect, but in the late visitation it showed itself to be quite at home in Rhodesia and in the east of the Transvaal, and for a short period it spread over parts of Namaqualand, Bechuanaland, Griqualand West and most of the Transvaal, Orange Free State and northern and eastern districts of the Cape Province. Some, probably all, of the locust visitations to the Cape Peninsula were by this species. It gives serious trouble in South Africa at much longer intervals than the Brown Locust, but seems to occur concurrently when it comes. Great swarms of it have come out of the Kalahari; but its liking for arboreal vegetation, and its marked preference for and persistence in tracts where there is a heavy growth of trees or bush, suggests that its really permanent abode is not in that almost treeless region. The last invasion of the colonies now comprised in the Union began about 1893, in which year it appeared in Natal, and was observed near Lake N'gami. Early in 1895 it was found in small swarms in Griqualand West and elsewhere along the northern Cape border, and also along the Transkeian coast, and late in that year it came south in tremendous swarms, seemingly across the whole country from Natal to Bushmanland. The swarms from Natal bore along the coast, and those from the Kalahari direction south-east, keeping to the east of the Carnarvon and Victoria West districts. Thus the invasion converged on the coast near Port Elizabeth; but it was continued westward in a broad belt along the south coast, becoming slower and diminishing in volume until it ceased in the Robertson and Swellendam districts early in March. The locust was recognised by the oldest inhabitants as one that had similarly swept over the country about fifty years before. It did not remain long on the southern seaboard nor in far inland districts, but it continued prevalent on the Natal coast, and generally along the coast eastward from Port Elizabeth, for many years. It fluctuated in abundance from year to year, but, on the whole, gradually retired farther and farther nortward. At the same time, it gave trouble in low veld parts of the Transvaal and Swaziland and in parts of Portuguese East Africa. Since 1909 it has given no trouble anywhere in South Africa, but last year it was reported to be rather prevalent in the north of German East Africa. Very little is known about its earlier occurences in South Africa. As

already stated, it ravaged parts of the Cape in the early forties of the last century. From 1847 to 1853 it was prevalent in Natal, so abundant at times, I have been told, that great branches were broken from trees by the sheer weight of resting flyers. A reliable correspondent (A. Meiring, Graaff-Reinet) has informed me that he saw a huge swarm at Kenhardt in 1869. The years 1842 to 1854, 1862 to 1876, and 1890 to 1909, it should be noted, were periods when the Brown Locust was also present in the country. The Red Locust was observed at Kuruman in 1826 by Missionary J. B. Moffat, and he wrote of it as if the natives knew to expect it after the Brown Locust came.

The Brown Locust usually appears on the wing in great swarms in March or later, and deposits its eggs before winter. The eggs hatch with the first soaking rains of the warm season, generally in October, and the insects become winged about two months later. The swarms then depart, their usual direction of flight varying in different sections of the Union, and being, perhaps, chiefly dependent on the prevailing winds. If the rains come late, the insect develops correspondingly late; and this fact being well known, late-appearing swarms have been regarded as late-developed swarms when the appearance of the insect indicated, as is often the case in the autumn, that it could not have been long on the wing. Rarely, apparently, do swarms develop both early and late in any one season at one place. It is therefore not surprising that the insect has been regarded as having only one generation in twelve months. Such an opinion is generally held, but conclusive evidence has accrued showing that the insect must have two generations in twelve months whenever it meets with soaking rains in the spring, and again after three to five months. The swarms that depart at midsummer are not the swarms that come three or more months later. The latter are later developed swarms, and may be, probably often are, the immediate descendants of the midsummer swarms. This condition of affairs was suspected in 1907, but was not proved until the 1913-1914 season, when two generations were experienced in an isolated outbreak in midland districts of the Cape Province. A scrutiny of old reports of locust occurrences, in connection with rainfall records in the light that two generations are possible, shows that two generations doubtless occurred in several years during the last great locust cycle. Eggs are deposited by the first generation about a month after the winged stage is reached, and the hatching may occur within another month. One record states that eggs laid in the middle of January, 1907, hatched within fourteen days. The eggs, as already implied, require moisture for their development. Popular tradition has it that in the absence of adequate moisture and warmth, they may retain their vitality for fourteen years. Tests made by the writer showed that they would hatch after three and a half years, and there is no reason to doubt that suitably preserved eggs would hatch even after a much longer period.

However, most of the stories of eggs hatching after many years have arisen from no better foundation than hoppers unexpectedly appearing after the lapse of so many years since locusts were last observed, and as I am now clear in my mind that locusts may occur in considerable numbers unobserved, I discount these stories heavily. Nevertheless I have records of eggs hatching after the lapse of ten years that I do credit, and I think it not at all uncommon for eggs to lie over one season.

The Red Locust has not been suspected of having more than one generation in twelve months, and there is no acceptable evidence that its eggs retain their vitality into a second season, nor that soaking rains are essential for their development. The adult insects live through the winter, most of the time, it is believed, in the shelter of forests or "bush," but occasionally venturing abroad. In the spring they mate and move about locally, or migrate in great swarms, evidently seeking feeding grounds and favourable places for egg deposition. Only the few general migrations alluded to in a preceding paragraph have been recorded, and it is really not known whether or not the descendants of the invading locusts of 1895-1896 were ever re-enforced by new invading swarms from a great distance. Egg-laying has been observed in Natal in early October, but early December is considered the normal time in that Province, and hatching is expected about thirty days later. In the Cape Province, egg-laying seems to average much later, and often to be prolonged into February and March; but hoppers in all months from October to June have been reported along the coast. Hatching in the abnormal months are, I think, owing to belated and irregular development, there having been nothing in the instances recorded to suggest a second generation.

I have given this almost too extended outline of our two locusts merely as a necessary preliminary to speculation on the causes that underlie locust visitations in South Africa. Be it understood that at irregular intervals, sometimes after no locusts have been observed for over a decade, vast swarms sweep out of the Kalarhari or down from uncertain regions in the north, spread over a tremendous area that may extend to two-thirds of the Union, do enormous damage to crops and to veld, and that thereafter, for a series of a dozen or more years, extensive areas are liable to be more or less devastated every season. In general, the plague is at its worst two or three years after it first manifests itself.

One common feature that the locust problem in South Africa has with the locust problem wherever else it occurs in the the world, is obvious association with large tracts of naturally arid country where the rainfall is both scanty and erratic. A little reflection will, I think, satisfy you that a gregariously-inclined migratory plant-feeding creature, be it springbuck or locust, or anything else, has decided advantages for continued existence in such a country over any similar creature that is

non-gregarious and non-migratory, and also that the former creature is out of place in a well-watered, humid country. Gregariousness in a humid country would increase the liability of the locust to bacterial and fungoid diseases, potent checks on multiplication where the air is moist, but almost inoperative in arid regions; while migration in a well-watered country is quite unnecessary as a provision against starvation. In an arid country with an irregular rainfall, such as the Kalahari, vegetation grows rapidly, and is plentiful after good rains. But most of the rains are local, and fall now in one place and now in another, thus tending to make any one place a land of plenty for plant-feeding insects at one time, but very liable to be a land of great want in a few months. Under such conditions it must be a great advantage to locusts to be able to seek pastures new. The insects must at times become very scarce indeed, and the instinct for them to keep together on their migrations, aside from probably affording some direct protection against complete extirpation by enemies, presumably acts indirectly to ensure the perpetuation of the species. If necessity to migrate arose when the numbers were small and each locust went its own way, comparatively few, I imagine, would meet with mates when the time for breeding came. Hence it appears to me that the gregarious migratory locust, capable of long-sustained flight, is a very natural development in a wide expanse of arid country with a desultory rainfall.

It has been recognised by most students of locusts that their migrations may be divided into two distinct classes, which, for convenience, I call local flights and true migrations respectively. Local flights are now in this direction, now in that, sometimes are only for a mile or two, but often for a score or more, and they seem prompted chiefly by a restless searching for suitable feeding grounds and for suitable places for egg deposition. True migrations are in some one general direction that is pursued by immense swarms day after day and sometimes week after week, and they are broken only for feeding and during unfavourable weather. Various theories have been put forward in explanation of these general flights, but I confess I find none of them satisfactory. Lately I have come to think that, despite all that has been written to the contrary, the keeping to a more or less set direction may be due chiefly to prevailing winds at the time favouring that direction. At times birds undoubtedly tend greatly to keep swarms in motion, and it may be that the fly parasites have a similar harassing effect; but the leading factor that keeps both the winged and hopping insects so continuously on the move may, I venture to suggest, be merely the irritating effect of their being crowded together at a season when they are naturally active.

I imagine a swarm to grow like a rolling snowball as it traverses a thickly-infested region. Then that, as it passes onward, it gradually loses in volume through the dropping out

of mating couples and spreading out from the sides, the impulse to migrate further in the one case being overcome by the encumbrance of developing ova, and in the other by liberation from the dense mass. The effect is to spread the insects over an area extensive enough to promise ample sustenance for the next generation, when even they themselves might perish through starvation if they were to remain in the region of their origin.

The chain of reasoning I have followed supposes locusts to be continually present in arid regions, from which occasionally they come in swarms; but, as a matter of fact, almost nothing is known of locusts in the intervals between their periods of abundance. Here is one important point on which reliable observations are necessary before our knowledge of the locust problem can be considered satisfactory, and it is a point which I think might easily be settled in South Africa with respect to the Brown Locust. I am inclined to believe this species to be permanently resident not only in the Kalahari and Bushmanland, but in Griqualand West, the eastern half of the Orange Free State, and northern and central parts of the Cape Province. By permanently resident, I do not mean that I think it common enough to attract casual attention, but that a careful watch would show it to occur in small numbers here and there in localities specially suited to it. It seems to me probable that even in the regions where the greatest swarms develop, it is for years at a time an inconspicuous insect. The present year is not a suitable one for observations on which to base definite conclusions regarding the habits of locusts between periods of abundance. This because, swarms being here and there in the country, it cannot be denied that scattered locusts might possibly be stragglers from swarms that may be imagined to have passed by unobserved. However, after the public was urged by repeated newspaper references to be on the watch, specimens reached the Division of Entomology from a number of points far distant from where any definite swarms were known to have been for years. And, moreover, the locusts in the parts that were most infested occurred principally in loose, open swarms, or clusters of a few score or a few hundreds, or even as scattered individuals or couples. There was a notable scarcity of compact swarms this year, and up to the time of preparing this address there have been no reports that suggest a migration as distinguished from local flights.

The causes that give rise to excessive multiplication are now merely conjectural, and intelligent observation bearing on the explanations that are offered are much needed. It is considered that, during a series of unusually dry years, grasshoppers, and plant-feeding insects generally, come to be held in check more and more by limitation of their food supplies, and less and less by predatory and parasitic enemies. It follows that, when a particularly good season comes along, the plant-feeder gets almost the full advantage of its potentiality for increase, always

excessive in insects. Locusts are not specially fecund, yet in one season, in the absence of checks, the Red Locust would multiply over fifty-fold and the Brown Locust a thousand-fold. The predatory and parasitic checks on most insects speedily re-assert themselves and soon again restore the normal balance; but, by forming large swarms and migrating, locusts may be thought to escape their checks to a considerable degree, and thus be in a position to continue to multiply abnormally much longer than the plant-feeders in general. The past summer furnished a large part of the Union with an illustration of this effect on many insects of a rainy season following a series of relatively dry ones. Grasshoppers, butterflies, moths, and plant bugs were extraordinarily numerous. For a while it seemed as if, before the growing season ended, the hordes of caterpillars would have eaten off every green leaf; but, long before the season closed, ordinary conditions were to a large extent restored, parasites and disease suppressing most of the ravaging insects in a surprisingly short time.

Whatever the immediate cause or causes of excessive increase in locusts, and the consequent formation of great swarms, I do not think it can be doubted that the fundamental cause is a cyclical climatic change in the region where the insects have their permanent home. Hence I think we must look to the meteorologist and other students of climate for some of the information necessary to unravel the mysteries surrounding these insects. From my superficial study of the general subject, I have become impressed with the fact that locust visitations in South Africa have closely followed long droughts that have been thoroughly broken up by widespread general rains. Moffat (*Missionary Labours*) mentions that the vast swarms he saw at Kuruman in 1826 came after a long and serious drought had given place to a good season. The years 1858 to 1862 are recorded to have been very dry years, 1862 being still remembered as one in which rivers ceased to flow that had never been known to fail before; and, quick on the return of good seasons, followed the locust cycle that reached its greatest height in 1864, but continued to 1876. Then 1883 seems to have ushered in another succession of bad seasons, broken late in 1889, and followed by a locust visitation that, first recorded in February, 1890, at Beaufort West, spread over the Transvaal and Orange Free State and much of the Cape Province in 1891, and reached its climax in 1893. A severe recrudescence of the plague followed when what was called a "great drought" in Bechuanaland, Transvaal, and Orange Free State (see *Cape Agricultural Journal*, **23**, 512) broke up with splendid rains late in 1903. This secondary visitation culminated in 1907, and settled parts of the Union were practically free from the pest in the following year. But 1908 was a dry year in the southern Kalahari, and after phenomenal rains there early in 1909, swarms again swept down over a large area of the Orange Free

State and the Cape. After that the plague subsided, and, as already explained, the cycle is regarded as having finished with the 1909 season. But another series of dry years began at once to creep over much of the country, and 1912 in particular was a drought year practically over the whole summer rainfall area of the Union A part of the Cape Province centring about Doornberg, in the Middelburg district, a region to which locusts are partial, received only about one-third its average rainfall in this year, but early in 1913 was favoured with good rains. At once locusts appeared here unexpectedly. Farther north, in the Fauresmith and surrounding districts, the drought continued until the past October and November; but when it finally broke, there locusts appeared also. The rains of the past summer, as intimated a few moments ago, were exceptionally good over much of the country, and general trouble with locusts may now be imminent again, as I stated in introducing this address. Yet the area in which we know them to have shown themselves this year, although its limits embrace nearly 100,000 square miles, is only a small portion of the great region that I regard as the probably permanent habitat of the species; and perhaps it is a relatively inconsequential portion in so far as excessive multiplication is concerned. Perhaps only when conditions are generally favourable for the breeding up of the pest over much of the enormous stretch of arid territory from Gordonia north beyond Lake N'gami is there danger of those mighty swarms developing that from time to time spread over so much of the country; and concerning the conditions that apply to locusts in that territory we are almost completely ignorant. My impression is that it is an immense dreary thirstland, where swarms of great magnitude might easily be produced and perish in the fulness of time without once having come under the observation of civilized man. Swarms are recorded to have been seen near Lake N'gami in August, 1889 (Sander: *Die Wanderheuschrecken*, p. 22), that is, eighteen months before locusts were seen in the Union in the 1890-1909 cycle; and the Red Locust was reported there in 1893 and at Palapye in October, 1894 (*Cape Agricultural Journal*, **9**, 331), whereas it was not found in Griqualand West until early in 1895. The query naturally arises: Does a cyclical change come down from the northward bringing locusts in its wake? Here again I look to students of climate for assistance.

The sudden appearance of the Brown Locust in large numbers after a drought, without there having been any invading parent locusts, is explained, I think, by the fact that eggs of this species preserve their vitality for years in the absence of adequate moisture for their development. I imagine that eggs accumulate during a series of dry years, and are all hatched under the influence of a soaking general rain. The bird and insect enemies of locusts would naturally be relatively scarce when the general hatching occurred, and thus the locusts, with plenty of food about

them, would be able to increase with comparatively little molestation. The Red Locust, so far as known, lacks the advantage of possibly indefinite suspension of development in the egg state and also of a second generation in one year. These differences from the Brown Locust may account for the Red Locust being a less frequent marauder of the Union, and also for its appearing on the scene a year or two later, but I think it not unreasonable to assume that there are peculiarities in the economy of the Red Locust that compensate to some degree for its longer life cycle and for the limitation of its egg stage. I shall not, however, detain you now with my surmises in this direction. The fact remains that the numbers of both species may increase most extraordinarily in the space of a few years, then fluctuate considerably, and more or less gradually subside until they altogether disappear from the common notice. I think the first rapid increase is accounted for by a comparative inadequacy of natural enemies following a cyclical change in rainfall, but the fluctuations that then occur away from the permanent habitat necessitate further guess work in my search for a suitable explanation. I find it difficult to conceive that the insects may increase again in their temporary abode once their enemies start their numbers on the downward course unless re-enforcements come from the arid regions. Our records of swarm movements indicate that some re-enforcements do come, but the origin of these swarms requires elucidation. I can only conjecture that extensive re-infestation of the relatively desert parts occur from the better watered regions, giving rise to the supplementary invading swarms, or that the checks are much less efficient in the permanent breeding ground, and that therefore the duration of the period of excessive numbers is more prolonged there. It has been surmised, even stated as a fact (*Transvaal Agricultural Journal,* July, 1907, p. 951) that the swarms of the Brown Locust bred in the temporary region in spring migrate to the permanent region and breed there in the summer, giving rise to swarms which then seek the temporary region in the fall; but there is really little definite data indicating instinctive return migrations. Reliable observations on the point are sorely needed. At present, I think that the return migrations that occur are due to wind movements and not to inherent inclination.

It seems quite possible that some of the enemies of locusts are less efficient against the insects in the Kalahari than in the settled parts of the Union, but here again exact observations are much needed. It has been plausibly suggested that, owing to the scarcity of surface water in the so-called desert, the large Locust Birds (*Ciconia* spp.) are unable to remain, and hence that the locusts there escape in large measure the inroads of these inveterate enemies.

The enemies of locusts are many and varied in every locust country, and South Africa has its full share. In all countries

birds are amongst the most obvious enemies, and from what is recorded on the subject, it seems to me that birds are a greater factor in locust suppression in South Africa than they are elsewhere. Here there are several kinds of birds that follow locust swarms from place to place, and are relatively very scarce or absent altogether in years when there are no swarms. Amongst the most important are two migrants from the northern hemisphere, *Ciconia alba*, here called the large Locust Bird, but in Europe the White Stork, and *Glareola melanoptera*, a pratincole reputed to come from southern Russia and south-western Siberia. Neither of these birds nest in South Africa. They usually arrive in October and November and depart during March, thus being here at the height of the locust season. The studies of German and Hungarian ornithologists have removed any shred of doubt that storks bred in the Baltic region and in Hungary are the storks that reach us. Many individual birds, leg-marked in their northern home with inscribed aluminium rings, have been found in the various provinces of the Union. So highly important do these and congeneric migratory birds appear to be in suppressing a locust outbreak when they become abundant, that one is inclined to think that progressive multiplication of the pest for a series of seasons may be possible only when these birds come to the country in small numbers. Here is another point on which observations are wanted. It seems possible that, as the locust swarms in South Africa become extirpated, the birds gradually cease to come so far south; and that, when great swarms again develop, the bulk of the birds are several years in discovering the fact. It has to be considered that other parts of Africa are subject to locust visitations, and that to reach this part the birds must traverse the continent from the extreme north-east. May it not be that, when the birds meet with a shortage of locusts here, they flock to some other part where the prey is more abundant, and is there not a remote chance that locust cycles in one region may thereby be made to alternate in a measure with locust cycles in another region? If this address is printed, and meets the eye of observers of locusts in other countries to which our locust birds go, I hope they will be good enough to communicate with me on this subject. And I hope that observers of locust birds in this country may be influenced by my suggestion to gather data on the relative members of the migrants from year to year.

There are many other matters in connection with the economy of locusts that I should like to touch upon; but I feel that I have taken up all the time that I can claim. But I leave the subject much regretting that by my absence I am deprived of discussing it further in private with members of the Association, who might, perchance, be able to give me information that I could turn to advantage.

Section D.—ANTHROPOLIGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY, AND STATISTICS.

President of the Section.—J. E. Adamson, M.A.

THURSDAY, JULY 8.

The President delivered the following address:—

THE CONTROL OF EDUCATION.

In this paper I shall endeavour to establish the proposition that the time has come when the control of school education should become a Union function. What is meant by control will appear as the topic is developed. To prevent any misunderstanding, however, it may be said at the outset that a central authority would not be able to concern itself with anything more than general principles and policy. A large measure of administrative responsibility would, of necessity, be delegated to local authorities. There can never be Union control of education in the same sense as there is Union control of, say, Posts and Telegraphs or Defence. The broad lines of the suggested division of responsibility and function between central and local bodies will appear as we proceed. Nothing more than outlines and frontiers can be indicated, and I should like to say at once that any opinions I may express, so far as they are derived from experience, are the outcome of experience obtained in this province of Transvaal. I am not so presumptuous as to express views with regard to other provinces. When I argue for Union control of school education, it is to be understood that I do so solely with a view to the educational welfare of Transvaal. Whether it is desirable elsewhere is for others to say. I fear the topic will not be a particularly interesting one for the layman. It is too far removed from what is for him the essential matter, namely, the progress of the individual boy or girl, and the progress of the community. It is a subject of fundamental importance, however, and one which is in a measure pressing; and I take it that it is the business of this association to endeavour to contribute towards the solution of such problems as they arise.

The present position with regard to the control of education is by this time well-known and understood, at any rate by all interested in the matter. Under the South Africa Act, school education, that is education up to and including the matriculation standard, is left to the control of the four Provincial Councils; while college or post-matriculation education is controlled by the Union Parliament. At the National Convention a horizontal cut was made across the educational pyramid. It is common knowledge that this division of function was the result of a compromise dictated largely by political considerations. Every-

one experienced in administering education realised at once that it gave to the Provinces by far the larger share of control. The less bureaucratic control of college education there is, the better it will thrive. It needs almost complete freedom for its development. Its various departments or faculties are more or less fixed by experience and tradition; in its methods it should be entirely free; and in the administration of funds, each institution should be given a very large measure of autonomy, thus the share of direct control over education, which the Union Parliament obtained under the South Africa Act, is very small. It may be observed, too, that the division is one which it has not been easy to maintain, obvious and definitive as the line of demarcation seems to be. For example, the training of teachers and technical education cross it in an embarrassing way, and the development of these vitally important branches of education has not been furthered by it.

Instead of the artificial and arbitrary division of education into higher and lower by means of what I have just referred to as a horizontal cut, a vertical line of cleavage passing from top to bottom of the educational pyramid is suggested, leaving legislation, embodying general principles and policy, to the central authority and administrative detail to local authorities. This suggested division, so far as it concerns the colleges, is to be understood to be subject to the limitation of bureaucratic control already urged.

The first reason for such a proposal is, so to say, a dictate of the national conscience, and may be reached by means of a question. Will a national assembly be content to divest itself permanently of effective control over, and final responsibility for, a national function? And ought it to be content to do so? It seems to me that the answer, both as regards fact and obligation, is in the negative. The experience of practically all other countries corroborates this, and there has been plenty of evidence during the last five years to show that the Union Parliament is restive under the restrictions which the South Africa Act imposes. There seem to be at least three fundamental reasons why this should be so. In the first place, education touches men more nearly than any other state function. It concerns the well-being of their sons and daughters. For this reason alone the members of the Union Parliament will inevitably desire to have a share in the direction of national policy in education. In the second place, the Union Parliament will demand control just because national education is a vital factor of national progress, whether we are thinking of material progress in the area of commerce and industry, of progress in a cultural as distinct from a vocational sense, or of moral progress. The close relation of the schools to national prosperity and morality is a truth which has at last found almost universal recognition: and this being so, the national voice will insist on being heard on matters of educational policy. In the third place, national schools should,

in a measure, reflect national aims and aspirations, should strive after the civic as well as the individualistic ideal. In South Africa there is, unfortunately, divergence of view with regard to these aims and aspirations: there is a clashing of ideals. This is, however, only an additional reason for discussing them in a national assembly.

Then there is unanimity, at any rate of voice, as to the desirability of keeping education outside the arena of politics and party. This consummation, so devoutly to be wished, will be attained if, and only if, a national policy acceptable to all parties, in respect of aims, principles, and administrative procedure, can be evolved and developed. There should be no insuperable difficulty, if the necessary measure of local freedom and option is provided. The subject is one around which passion and prejudice notoriously range themselves, and nowhere more frequently than in South Africa; yet the problem should not, I repeat, be difficult of solution. The Provinces have accumulated a store of experience which indicates the broad lines a national policy must take. What is needed is an atmosphere where the sound, the tolerant, and the long view is likely to prevail. Where else is it likely to be found than in the national assembly, where the leaders of the nation foregather? Provincial Councils, in some instances at least, have developed along party lines, and there is no question that in one case education has been sacrificed in the clashing of party interests. If party politics are to prevail in Provincial Councils as well as in the central assembly, then educational principles and policy will be safer with the bigger and more completely representative body.

It has been suggested that the assumption of control over general principles and policy by the national assembly would involve the delegation of a large measure of administrative responsibility to local education authorities. This control would be exercised mainly through legislation, and it is a corollary of the argument just used, *i.e.*, that the magnaminous view is more lively to prevail in the national assembly, that legislative functions should be exercised by that body and by that body alone. Legislation to the central body and administration to the local bodies represents roughly, though not with any exactness and completeness, the line of cleavage I should suggest. Apart from the fact that the veto is an instrument which, as experience has shown, is likely to prove an irritant if it has to be frequently invoked, educational legislation being as it is, of such far-reaching individual and national importance should become a Union function.

The desirability of equality in the distribution of the financial burden also points to the need for central control. Existing inequalities are undeniable. One Province, Transvaal, finances education entirely from the Provincial exchequer, which is fed by the Union subsidy and certain assigned revenues; that is to say, it depends entirely upon Union bounties. A second, the

Cape Province, imposes in addition both taxation and fees. The two remaining Provinces, Natal and the Orange Free State, impose fees. There is clearly a case for reform here. What should the nature of the reform be? The first point can be asserted with confidence. It is that there should be in all cases a real division of the financial burden between the central and local authorities. On the one hand, it is certain that the systems of education which have been evolved cannot be carried on without substantial Union grants; on the other hand experience here corroborates the experience of other countries, and leads inevitably to the conclusion that local contribution is necessary, both to develop local responsibility and initiative, and to check local extravagance. The principle of central and local contributions is thus the first financial principle urged. The second is uniformity, or, perhaps, it would be better to say equity, with regard to the central contribution. Details with regard to the form this contribution might take will be given later. Here it is only necessary to say that the grants should be equitable as between Province and Province, and to make them equitable economic conditions such as rent, wages, cost of commodities, would have to be taken into consideration.

As regards the local contribution, in the third place, the limits would no doubt be fixed by legislation passed in the Union Assembly. These limits should be wide enough to give a progressive community the chance to pursue a progressive educational policy. Initiative, the spirit of competition, and readiness to make sacrifice for what is believed in, are as desirable and necessary in a community as in an individual, and in the matter of the provision of educational facilities should be encouraged, within the necessary economic limits, as much as possible. The form which the local contribution might take, whether an *ad hoc* tax, the assignment of some share of general local revenue, or fees, or more than one of these, would doubtless be laid down by legislation; but I hold the view that such legislation should provide for a considerable degree of local freedom and option.

It is not necessary to urge that an efficient, secure, and contented teaching staff is an essential factor, indeed the vital factor, of success in any scheme of education. The supply, training, conditions of service, and retiring allowances, of teachers are the very crux of the problem; and it is, in my opinion, essential that all these matters should be under central direction and control. The supply is notoriously inadequate; and the organisation of the means of recruiting is a pressing problem which can only be effectively undertaken by a central body. At present the Provinces are scrambling for recruits. Various methods of training are in existence. It is not for a moment suggested that there should be any rigid uniformity of method. There is, however, a pressing need for organisation and co-ordination of the various schemes of training. At the early stage we have,

on the one hand, the pupil-teacher system and, on the other, an untrammelled high school education with superimposed Normal College training. Each province issues its own teachers' certificates, and they certainly do not connote the same thing. A teacher passing from the service of one provincial education department to that of another, finds that his professional passport does not open all doors. Again, while the provincial authorities are busy with the courses for the Third and Second Class Certificates, the Union Department of Education deals with the course for the certificate of the first class; and there is at the moment no relation of any kind between the certificates issued by the Province and the certificate issued by the Union. Finally, the relation of the Normal Colleges to the faculties of pedagogy in the University Colleges in the business of training teachers, should be, but is not, clearly set out. As regards conditions of service, there are wide divergencies. In some instances teachers are officers of the Provincial Education Department; in others they are the officers of School Boards. Salaries differ widely. Service in one Province does not count as service for another Province. Retiring allowances are varied. All these reasons support the policy of putting matters concerning the teaching staff under the control of the central authority.

Technical education, with all its importance and potentialities, is in the same unsatisfactory condition as regards control. The Union Department of Education has appointed a National Board, and this Board has adopted a scheme along the lines of which technical education might proceed. But the Board is advisory, and its scheme may remain in the air; for the technical schools (as distinct from technical colleges) dealing with trades and industries, commerce, and domestic science, are under the provincial authority and are developing independently. Their relation to the Board's scheme is entirely accidental and inarticulate.

All these arguments seem to me to lead to the conclusion that the Union Parliament should take over responsibility for the control of education so far as general principles and policy are concerned. I will now indicate the general lines which a division of function between the central and local authorities might follow. There is a presupposition which must be asserted with all possible emphasis. The assumption of a measure of control by the central authority must mean, of course, the introduction of a certain degree of uniformity. The last thing desirable, however, is uniformity of content, uniformity in the nature of the education given. One hears vague talk of unification of education, of developing a single national system, and the like. Reformers on these lines should be heard with caution. So long as they are referring to uniformity of financial relations, of administrative machinery, of final aim and ideal, all is well. If, however, they have any notion of fitting all pupils to the same groove, without regard to differences of

environment, of industrial conditions, of language, and of future vocation, all is wrong. The essence of education is variety and individuality. A child, a school, an inspector's circuit, a school board district, and a province, should have individuality, real and vital; and should guard and develop it. Rigid uniformity of method and of organisation may be appropriate to some state functions, but it is the death-knell of sound education.

Having this warning in mind, we must first consider how far the ceneral authority should control the character and form of the education given in the schools. Its first duty would be to define clearly what may be expected from the primary school course, and what from the secondary school course, and in the term secondary school I include technical as well as general institutions; it would also decide the delicate question of the relation between the two. This would involve prescribing the subjects to be taught and the ground to be covered at the two stages. How far the central authority should develop detailed curricula in the various subjects, is an important point, and one about which there is considerable difference of opinion, even among those who profess education. On the one hand, there is the view that requirements should be laid down in detail by the central authority, and should be generally adhered to; while, on the other hand, there are the advocates of freedom for the individual teacher to develop the details of his own course. There is no doubt that such freedom is a desirable thing in itself, because it stimulates professional interest, and because it leads to that variety whose importance has just been emphasised. One must keep one's feet on the facts, however, and it is unquestionable that full and final responsibility for the development of curricula cannot with safety be left to individual teachers. In many cases their professional capacity and experience are low, and in most cases a broad and just estimate of educational values cannot be expected. It is certain that for a considerable time to come, responsibility for the organisation of curricula would rest with the central authority. In order, however, to encourage professional initiative, the practice of recognising schools as eligible to submit alternative curricula might be introduced from the first.

It is important to remember also that the primary course must of necessity be to a large extent the same for all. It deals mainly with essential instruments of knowledge and intercourse, such as reading, writing, and computation, and requirements here are clearly defined by experience and tradition. As regards formative subjects, such as religious and moral instruction, geography and nature study, history and the elements of citizenship, a certain amount of latitude with regard to choice of subject-matter could be permitted. The secondary course would present far greater variety. What we might call the general cultural form of secondary education which aims at matriculation, would of necessity follow well-marked lines; though, within

the limits prescribed by the matriculation syllabus itself, more and more differentiation is becoming possible. The more directly vocational forms of secondary education—commercial, industrial (including agricultural), and domestic—would, of course, be largely distinct the one from the other.

At the secondary stage the central department would probably limit itself to prescribing requirements in general terms. The vital question whether it would be content to let the development of the courses in secondary schools of a general character be decided by the requirements of an external body, as contained in a matriculation syllabus, cannot be handled here. A secondary school leaving certificate issued under the authority of the central department, which would be acceptable as a university college entrance qualification, is, of course, the desideratum. I may add here that it would be the duty of the central department, perhaps its most important duty, to set out the objective of a national system and to see, by means of its inspectoral staff and all other possible channels of inspiration, that the aim was understood and pursued. I may state what my own view of that objective is. Ability and potentiality should be set before actual attainment, and should be secured through the development of curricula in which both vocational and cultural studies are provided for. The civic as well as the individualistic ideal should be sedulously fostered.

What the constitution of the local authority might be I am not prepared to discuss, since the question is locked up with political considerations. Whether the Provincial Councils remain, or whether something of the nature of District or Divisional Councils replace them, does not affect the argument I am endeavouring to develop. One opinion may be asserted with conviction. If the provincial machinery is abolished, the administrative unit which deals with education should be large, and should embrace both urban and rural dictricts. Under the scheme being suggested, it would have to raise public moneys, and though the conditions under which it would administer the funds derived both centrally and locally would be prescribed by legislation, the responsibilities would be great. Wise and impartial administration would only be secured if it were in the hands of a body representing wide and varied interests. The powers of such a body wolld be far greater than those of the Advisory School Boards of the Transvaal. Within the limits prescribed by legislation it would assume responsibility for all school education within its area, with the possible exception of native education. Its chief function would be to provide and organise facilities, and to see that they were taken advantage of.

The position of teachers under the scheme outlined would need to be precisely defined. The development of a well-qualified and contented body of teachers is an essential of success. Teaching is an arduous vocation, and the service must be made as attractive as possible if the desirable recruits are to be

obtained. It will not attract the best men and women unless the following conditions are fulfilled: Adequate salaries, reasonably liberal conditions of service, especially leave conditions, proper status and security of tenure, and a pension on retirement. It would seem that the central authority should secure the first three of these conditions by requiring their fulfilment as a basis of its grants to the local authority. The grades of posts and salaries attached thereto should be laid down by the central authority. These salaries should be the minima payable: the local authority being at liberty to raise emoluments beyond the minima, if it were prepared to raise the necessary funds. As regards the fourth—namely, pensions—I should suggest that the Union Parliament contribute towards a pension fund for all teachers placed on the permanent establishment. The position would then be this: The local authorities would recruit and appoint their own teachers, but the conditions of service would be such as were laid down by the central authority; after a probationary period, a qualified teacher would be admitted to the regular teaching staff; and, once having been admitted, his tenure and retiring allowances would be secure, so long as his service and conduct were what they ought to be.

We may now consider the financial relations that might obtain between the central and the local authorities under such a scheme as is contemplated. It has already been suggested that there should be a real sharing of the burden. The central authority would make grants of a character to be suggested immediately, while the local authorities would supplement them with moneys raised locally, and would administer the total revenue obtained from central and local sources. Existing financial relations will have to be put out of consideration for the purposes we have in view. The present position in the Transvaal is that all moneys required for school education come from the provincial exchequer, and this is fed by Union grants and certain assigned revenues. These grants and these revenues are expended not only on education but on other provincial services. In order to get a clear view of a reasonable distribution of the cost of education, it will be simpler to consider the question without any reference to existing financial conditions.

It may be assumed, for the purposes of the argument, that the central authority would give financial assistance in the following ways:—

(1) By taking over charges connected with central, as distinct from local, administration, inspection, the training of teachers, the education of non-European children, and contributions to a teachers' pension fund;
(2) By contributing on a capitation basis to the funds required to meet current expenditure on schools;
(3) By making building grants.

We may now inquire what the financial position would be under these circumstances.

For the financial year 1915-1916 the sum of £789,448 was provided on the Education Vote. This sum does not include expenditure connected with the erection, hiring, furnishing, cleaning, heating, lighting, and sanitation of buildings. These charges will be dealt with in a moment. The services which I have suggested under (1) above, as those which would be taken over by the central department, are estimated for the year in question to cost £108,623. This leaves £680,825 as the total amount to be found, excluding moneys required in connection with buildings. Suppose, now, that Parliament decided on capitation grants, mentioned under section (2) above, and that such grants were to be based on the average enrolment. It would clearly be necessary to have at least two scales of grants—one for primary and one for secondary, including technical, education. The cost of primary education based mainly on salaries has gradually approached £8 per pupil in Transvaal, and I think this figure might be assumed to be the capitation grant for primary education so far as Transvaal is concerned. Of course, such a figure would always have to be subject to revision. As regards secondary education, the corresponding figure might be put at £12 per pupil. This is considerably lower than the actual amount expended even before fees were abolished. The figure for the calendar year 1913 was £14 12s. 8d. It seems to me, however, that the figure for secondary education should bear a constant relation to that of primary education, and for various reasons, which I need not elaborate here, the proportion of three to two seems to be a reasonable one.

On the 30th September, 1914, there were about 66,500 children receiving primary education and about 3,500 receiving secondary education in the Province. These figures are not exact, but they are near enough for the purpose in view. The capitation grants would, on these figures, work out as follows:—

$$\begin{aligned} 66{,}500 \times 8 &— £532{,}000 \\ 3{,}500 \times 12 &= £42{,}000 \\ & \overline{£574{,}000} \end{aligned}$$

If this amount is subtracted from the total amount required, £680,825, there remains the sum of £106,825 to be raised by local contributions. This works out at about 19 per cent.

Recurrent charges in connection with buildings, as detailed above, are estimated at nearly £120,000 for 1914-1915 (selected because it is a normal year so far as buildings are concerned). On the assumption that funds for this expenditure would be provided locally, the total local contribution would amount to about £226,825.

I am assuming that building grants would be made by the central authority as at present. The amount expended on new buildings for Transvaal schools has varied in recent years. It

stood at £186,060 for 1913, which is the highest figure reached. If it be assumed, as it may, that a very considerable amount of progress has been made with the provision of new school buildings in the Province, an annual contribution of £150,000 would certainly not be illiberal. This figure would, of course, be subject to revision from time to time.

On the hypotheses assumed in the above argument, the position would then be:—

Central Contribution.		*Local Contribution.*	
To meet the cost of central administration, inspection, training of teachers, education of non-European children, and contributions to teachers' pension fund	£108,625	To meet the cost of carrying on the schools..	£106,825
Capitation grants	574,000	To meet recurrent expenditure on buildings and equipment	120,000
Building grants	150,000		
	£832,623		£226,825

This would mean that 27 per cent. of the assumed total expenditure on public education would be borne by local contributions. Whether Parliament would approve of the imposition of this local burden it is, of course, not possible to say. Local authorities in older countries have a heavier burden. Thus, from the 1913-1914 figures, it appears that in Scotland the central government provides about 63 per cent. and the local authorities 37 per cent. of the expenditure on public education. Corresponding figures for England and Wales (1911-1912) are about 59 per cent. and 41 per cent.

One word, in conclusion, with regard to the control of native education. In dealing with financial relations I assumed that the central authority would retain the funds provided for this purpose and administer them; in other words, that native schools would not fall within the supervision of the local authorities. The present position in Transvaal is that schools for Eurafricans do so fall, while aided mission schools for aborigines do not. I believe the same difference as regards control exists elsewhere in South Africa. If the schools for Eurafricans remained under the local authorities, as they well might, a capitation grant in aid of their maintenance would be necessary. The education of natives is a matter about which there are such acute differences of opinion that it would probably be advisable to vest control of native schools entirely in the central authority for the present.

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

SECTION A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE, AND IRRIGATION.

MONDAY, JULY 5.

1. Address by F. E. KANTHACK, M.I.C.E., M.I.M.E., President of the Section.

TUESDAY, JULY 6.

2. Fire resisting materials in building construction. By A. H. REID, F.R.I.B.A., F.S.A., F.R.San.I.
3. On the discrimination of the General Conic. By Prof. J. P. DALTON, M.A., D.Sc.
4. On the Gamma or Factorial Function. By Prof. W. N. ROSEVEARE, M.A.
5. Transition from Elementary Algebra to the Calculus, without Infinite Series. By Prof. W. N. ROSEVEARE, M.A
6. Note on the intersection of two curves whose equations are given in polar coordinates: with an illustrative example. By Prof. L. CRAWFORD, M.A., D.Sc., F.R.S.E.
7. The measurement of the natural ionisation of the air. By E. JACOT, B.A.

WEDNESDAY, JULY 7.

8. Secular change in the period of U Carinæ. By A. W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E.
9. Presentment and proof in geometry: a study of the associated circles of the triangle. By Rev. F. C. KOLBE, B.A., D.D.
10. Some aspects of modern naval development. By H. C. KENWAY.
11. The masses of visual binary stars. By R. T. A. INNES, F.R.A.S., F.R.S.E.

FRIDAY, JULY 9.

12. Modern topographical methods and instruments. By W. C. VAN DER STEER.
13. Preliminary notes on the intensity of rainfall in the Transvaal. By G. W. COX, F.R.Met.S.

SECTION B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY, AND GEOGRAPHY.

TUESDAY, JULY 6.

1. Address by the late H. KYNASTON, M.A., F.G.S., President of the Section.
2. The mineral spring on the farm Rietfontein, District Brandfort, O.F.S. By Prof M. RINDL, Ing.D.
3. Notes on the chemistry of the !Naras (*Acanthosicyos horrida* Hook). By W. VERSFELD, B.A., D.Sc., and G. F. BRITTEN, B.A.
4. Contributions to the chemistry of the Soya bean. By Prof. P. D. HAHN, M.A., Ph.D.
5. Notes on the chemical composition of Karroo Ash. By C. F. JURITZ, M.A., D.Sc., F.I.C.

WEDNESDAY, JULY 7.

6. The intrusions in the Parys granite. By Prof. S. J. Shand, Ph.D., D.Sc., F.G.S.
7. The Fault Systems in the South of South Africa. By Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.
8. Some features of the Rand Gold Mining Industry. By W. A. Caldecott, D.Sc.
9. Radioactive minerals in South Africa. By Prof. P. D. Hahn, M.A., Ph.D.
10. Can lithia be a constituent of plant food? By Prof. P. D. Hahn, M.A., Ph.D.
11. Atoms, old and new. By Prof. D. F. du Toit Malherbe, M.A., Ph.D.
12. The Rand Gold. By Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.

FRIDAY, JULY 9.

13. The profession of Pharmacy: suggestions for reform in its mode of attainment. By Prof. J. A. Wilkinson, M.A., F.C.S.
14. Loog-as; or the ash of the alkali bush. By A. Stead, B.Sc., F.C.S.
15. Geography. By J. Hutcheon, M.A., F.R.G.S.

Section C.—Bacteriology, Botany, Zoology, Agriculture, Forestry, Physiology, Hygiene and Sanitary Science.

TUESDAY, JULY 6.

1. On the variability in the nature or temperament of wild animals in captivity; with special reference to South African species. By A. K. Haagner, F.Z.S.
2. The effects of droughts and of some other causes on the distribution of plants in the Cape region. By Prof. R. Marloth, M.A., Ph.D.
3. South African agriculture: an analysis. By P. J. du Toit.
4. The ostrich feather industry in South Africa. By R. W. Thornton.
5. A factor in the evolution of plants. By Prof. H. A. Wager, A.R.C.S.
6. Experiments in crossing Persian and Merino sheep. By J. Burtt-Davy, F.L.S., F.R.G.S.
7. Some observations on the life history of the Pepper-tree caterpillar (*Bombycomorpha pallida*). By D. Gunn.
8. On the desirability of founding a South African Entomological Society. By A. J. T. Janse, F.E.S.
9. Anti-venomous serum and its preparation. By F. W. FitzSimons, F.Z.S., F.R.M.S.

WEDNESDAY, JULY 7.

10. Address by C. P. Lounsbury, B.Sc., F.E.S., President of the Section.
11. The Miners' Phthisis of the Rand. By W. Watkins-Pitchford, M.D., F.R.C.S., D.P.H.
12. The peril of Pyorrhea, and the results of three years' experimentation. By F. W. Fitzsimons, F.Z.S., F.R.M.S.
13. The problems and principles of malaria prevention. By A. J. Orenstein, M.D.
14. The effects of snake venom on domesticated animals, and the preparation of anti-venomous serum. By D. T. Mitchell, M.R.C.V.S.
15. Notes on the functions of colour in certain South African reptiles and amphibians. By J. H. Power.
16. Notes on a few trap-door and other spiders of Alicedale, Cape Province, By F. Cruden.

THURSDAY, JULY 8.

17. Preliminary list of South African fungi, represented in the Mycological Herbarium, Pretoria. By I. B. Pole-Evans, M.A., B.Sc., F.L.S., and Miss A. M. Bottomley, B.A.
18. On the occurrence of *Bacterium campestre* (Pam.) Son. in South Africa. By Miss E. M. Doidge, M.A., D.Sc., F.L.S.
19. On a method of making permanent preparations of superficial fungi. By Miss E. M. Doidge, M.A., D.Sc., F.L.S.
20. Some notes on the South African aloes. By I. B. Pole-Evans, M.A., B.Sc., F.L.S.
21. A new smut on *Sorghum halepensis*, which may possible affect Soudan grass. By I. B. Pole-Evans, M.A., B.Sc., F.L.S.
22. Note on the genus *Coniothecium* Corda, with special reference to *Coniothecium chomatosporum* Corda. By P. A. van der Byl, M.A., F.L.S.
23. Die-back of apple trees caused by *Cystospora leucostoma* (Pers.) Sacc. By P. A. van der Byl, M.A., F.L.S.
24. Notes on some of the South African *Stapeliæ*. By Miss S. M. Stent.
25. South African *Hepaticæ*, or Liverworts. By T. R. Sim, F.L.S.

FRIDAY, JULY 9.

26. A criticism of Lotsy's theory of evolution. By Prof. S. Schönland, M.A., Ph.D., F.L.S.
27. Dietetic defiency. By H. H. Green, B.Sc., F.C.S.
28. On the preservation of the monuments of Nature. By H. G. Breyer, Ph.D.
29. The problem of horse-sickness. By Sir A. Theiler, K.C.M.G., D.Sc.
30. Ostrich chick diseases. By J. Walker, M.R.C.V.S.
31. Sarcosporidia. By G. van de Wall de Kock, M.R.C.V.S.
32. The agglutination test, with particular reference to its use in the control of contagious abortion in cattle. By E. M. Robinson, M.R.C.V.S.
33. Observations on the evolution of birds, with special reference to South African forms. By A. Roberts
24. Game and bird protection in South Africa: a short comparison with some other countries. By A. K. Haagner, F.Z.S.
35. The influence of the climatic and tellurical factors on the distribution and spread of certain animal diseases, with special reference to the conditions occurring in South Africa. By D. Kehoe, M.R.C.V.S.
36. Termite economy. By C. Fuller, F.E.S.

Section D.—Anthropology, Ethnology, Education, History, Mental Science, Philology, Political Economy, Sociology and Statistics.

TUESDAY, JULY 6.

1. Economics of the War. By E. C. Reynolds.
2. The real object of Natural Science. By N. Mudd, M.A.
3. Professor Freud's psychopathological theories. By G. T. Morice, B.A., K.C.
4. An actuarial analysis of the loan schemes of certain Rand Building Societies. By Prof. J. P. Dalton, M.A., D.Sc.

WEDNESDAY, JULY 7.

5. African Native Melodies. By Rev. W. A. Norton, B.A.
6. The Baganoa or Ma-laboch: notes on their early history, customs, and creed. By Rev. N. Roberts.

7. The "Kgoma" or initiation rites of the Bapedi of Sekukuniland. By Rev. N. ROBERTS and C. A. T. WINTER.
8. A critical examination of the methods used for counting in elections by the single transferable vote. By J. BROWN, M.D., C.M., F.R.C.S., L.R.C.S.E.
9. Some problems of physical continuity. By Rev. S. R. WELCH, B.A., D.D., Ph.D.
10. Medical inspection of schools in relation to social efficiency. By C. F. L. LEIPOLDT, F.R.C.S., L.R.C.P.

THURSDAY, JULY 8.

11. Address by J. E. ADAMSON, M.A., President of the Section.
12. The constitution of the Senate. By F. FLOWERS, F.R.A.S., F.R.G.S.
13. The simplification of English. By Prof. A. S. KIDD, M.A.

FRIDAY, JULY 9.

14. Rhodesian ruins and Native tradition. By Rev. S. S. DORNAN, M.A., F.G.S.
15. The literature of France during the great Revolution. By Prof. R. D. NAUTA.
16. An inquiry into the origin of some South African place names. By Rev. C. PETTMAN.
17. The economics of the East Coast Fever. By Rev. J. R. L. KINGON, M.A., F.L.S.
18. Native Agriculture. By Rev. J. R. L. KINGON, M.A., F.L.S.
19. Practical education. By W. J. HORNE, A.M.I.E.E.
20. Slavic Austria. By Rev. W. A. NORTON, B.A.
21. Proportional representation. By R. P. KILPIN.
22. The relation of body and mind. By Rt. Rev. A. CHANDLER, M.A., D.D.

TERMITE ECONOMY.

By Claude Fuller, F.E.S.

I should like to touch briefly upon some of the new facts regarding termites which have come under my personal observation during the past two or three years, and to refer to one or two features of their economy which appear to me of particular interest.

It is not proposed to deal at length with any one phase, and my contribution will have served its purpose if it shows that some advance has been made, and better still if it should awaken some more general interest in these insects. A considerable amount of data regarding the distribution and behaviour of the various species has yet to be obtained, and this can only be so gained by accessions to the ranks of observers, at present no stronger than the writer, his official colleagues, and a few non-scientific friends.

I think it may be safely said that the biological interest attaching to termites is very much greater and very much more varied than that pertaining to any other insect group. Their social habits, the systematic cultivation of fungi by some, the singular preparation of stomodæal and proctodæal foods, the multiplicity of forms displayed by any given species, the peculiar insect-creatures which associate with them, their general parasitism by infusoria, their mining and architectural activities, are all both separately and collectively arresting; and, at the present moment there is no telling to what remarkable revelations the elucidation of any one of these aspects may lead, nor what important bearing it may have upon some other obscure problem which Nature presents. Here in South Africa the opportunity for all to make some novel discovery regarding termites stands ever ready to be embraced.

The practical interest they evoke is rather general, because of the mischief done by some to woodwork, to fruit-trees, and to crops. Here at least one would expect to find the field well explored, but this not the case. Much has yet to be learned because, whilst damage is often heard of, and wonderful tales are often told, the actual culprit has but seldom been determined—it is just a white ant—and in some cases habits have been attributed to species which do not possess them.

Somewhat apart stands the relationship between the activities of termites and the spread of trees and bushes, and together with this feature the good they do, or at least, have accomplished through past ages as soil improvers.

According to my references, we have quite a number of different species in South Africa, but the list probably indicates more kinds than have really yet been discovered, notwithstanding the fact that as many as eight new species have quite recently been added. This peculiar position arises out of the fact that

some species have been erected upon winged forms alone and others upon the soldier caste only. Of comparatively few kinds are the winged and soldier castes definitely associated, a matter which is only possible when the opportunity occurs to secure both castes from the parent nest. Again the list is without doubt amplified, because many of the criteria relied upon for the differentiation of species are not so reliable as they have been taken to be.

Upon the other hand the country as a whole has been so little surveyed for termites that there must remain a number of kinds still unknown to science. For example, I know of no species having been recorded from Basutoland or Griqualand East. Very few indeed have been recorded from the Cape, and but two of some seven that I have obtained from the Orange Free State have been previously mentioned from that Province.

It occurs to me that a further knowledge of distribution may show that environment has a marked effect upon the variation of several species, in both form and habit.

The conditions under which the nests of certain termites and shrubs and trees are associated have led me to the conclusion that "park-formation," as we know it in this country, is entirely due to these insects. It is extremely probable that, apart from untoward circumstances, a colony of termites exists for a considerable period; some species thriving much longer than others. What that period is, cannot be said for any kind, still there is some evidence to show that Haviland's *natalensis* thrives for a decade or more. But it must be conceded that ultimately the colony dies out. In the case of mound-building kinds, as long as the colony exists, the natural weathering is repaired, but when it dies the mound erodes and incidentally forms a piece of cultivated ground. Ample evidence has been collected to show that these old sites are again and again re-colonised, and with every successive occupation they increase in area, if but little in height.

Both the weathering of the occupied mound and the erosion of the deserted mound afford shrubs and trees, that cannot gain a foothold in normal grass-veld, a suitable spot in which to thrive. How their seeds get to the mound matters little; how the variety of plants becomes so great as it is, is readily understood, because such park-formations are only met with in grassy country more or less contiguous to timber belts and in and about what we in South Africa call bush-veld.

That certain termites derive some direct advantage from the presence of trees and shrubs upon their mounds is evidenced by the fact that whilst they do not permit grass to grow upon the mound, they do not interfere with deep rooting and stronger growing plants. To a large extent the advantage is against the full effect of storms, and possibly the root-systems of the trees afford some barrier to the predatory incursions of the *aard-vark*.

Up to the present I have not been able to locate a clump of trees of typical park-formation in which the soil is not raised

above the level of that surrounding, and in which a termite colony is not established. It may be urged that the termites select the tree clumps and do not originate them, and there is ample evidence to show that the species which commonly inhabit the clumps select the shelter of trees when available. Thus in many hedgerows and beneath ornamental trees, particularly about Pretoria, nests occur which are younger than the plants which shelter them. So consistent a feature indicates that the termites have selected the sites in which their nests are found. Again, I recently explored an orange grove on the Buzi River, near Beira, in which, beneath the shelter of almost every large tree, mounds from 5 to 8 feet were built up around the trunks, by Hagen's var. *mossambica* of *Termes bellicosus*.

But against this is to be set the fact that the commonest species associated with park-formation in Natal abounds and flourishes far afield in the open savannahs of the high lands, demonstrating at once that it at least is not dependent upon tree protection.

An examination of the underground workings of several common kinds has brought to light one or two features of more than passing interest.

The Harvesting Termites (*Hodotermes*) familiar as grass-cutters and despoilers of lucerne and oat and wheat crops, were found to excavate large subterranean cavities for the storage of their hay, filling them with tiers of shelving composed of carton and paper-like material of quite a unique form, and possessing quite peculiar architectural features. In the case of two species an additional form or caste was found, the significance of which is at present obscure.

The termite whose nests are recognised by the great air-pits which they make in the soil, or the chimneys with which these are often surmounted, was found to be a harvester of grass and grass seeds. It possesses granaries peculiar to itself and quite apart from the nest and its annexes. These granaries are cavities, empty except for a most complicated system of clay shelving, and remarkable because the harvest of seed is buried away in the surrounding soil. It is well known that many true ants store up seeds in their underground caverns, but this habit has not previously been recorded for any termite.

Concerning the commonest of African termites (*Eutermes trinervius*) whose rounded mounds are the one striking feature of the landscape in many parts, it was found that wherever these abound the nests are in more or less direct communication with one another. From all radiate permanent uniform roadways, almost exactly an inch below the soil surface, and much of the length of all seems to be the common property of several communities. These roadways lead out to the feeding grounds to which the insects journey each night to collect grass. All along them are small purse-like extensions, remarkably uniform in both shape and size, in which much of the grass is deposited as harvested. This termite is commonly regarded as a harmless

creature, useful to the farmer as chicken food, to the household as providing suitable material for making dargai floors and to the "sport" as an excellent thing for tennis courts. Ample evidence has, however, been collected to show that in drier parts of the country, not only does it remove a large proportion of the grass, but renders patches of the veld practically sterile. In short, it seriously reduces the feeding value of any piece of ground it occupies, and, in time of drought, its depredations are of vast significance.

Speaking of termites as a whole, my investigations have shown that grass is their normal food. The majority prefer it dry, and those that collect green grass deliberately make hay, or rather chaff, of it. The destruction of living trees is restricted to very few species and seems to occur only when the natural surroundings of the nest have been arbitrarily interfered with. The predilection which all except the harvesting termites display for dead and, especially, decaying wood is so very marked that this may be said to be their food by preference.

Up to the present, the evidence connecting species directly with damage of the sort usually complained of goes to show that only a few species are involved. All the damage to buildings which I have observed has been done by one of two species, Haviland's *natalensis* and *badius*, the latter being very rarely the culprit. The bulk of the destruction of young trees is done by *natalensis*, and it is only occasionally that other species are concerned in it.

Perhaps the principal feature of interest that I have been able to establish is that the oft-repeated statement to the effect that the adults or winged insects are incapable of founding a new colony, unless adopted by stragglers from another, is incorrect.

Up to the present I have been able to induce four different species to establish young colonies and maintain themselves and their progeny under most artificial conditions for periods now ranging from three to six months. From the progress made in this connection, it would appear that the adult termites are able to sustain themselves and at the same time feed and rear a number of young, without taking nourishment.

Nothing is perhaps more elusive than the impregnation of the female termite, and nothing indicating direct relations between the two sexes has yet been observed. Whilst this is the case, and the fertilising of the ova is still a mystery, mating, under natural conditions, during the marriage flight has been noted in the case of five species. In each of these the details of the procedure differed in small but essential particulars. In every case mating occurs after the insects come to rest, and it is always the female which first alights, and no sooner is this done than the creature endeavours to attract a male to her, by inflating her abdomen and directing it upwards. In all cases it would appear that the male is directed by an olfactory sense, and it is obvious that some females are much more potent in attracting than are others. In one species, the females, when coming to rest, throw

off their wings before attempting to influence a male, and when attracted, the male also dealates and seeks his spouse on foot. In the case of others, the female attaches herself to a prominent object, clinging head downwards, some kinds resting quietly. as if content in the strength of their special aroma, another violently agitating the wings, as if conscious of the weakness of its aroma, and the desirability of aiding its distribution.

In all cases the male insect, upon first meeting the female, combs her caudal apex with his mouth parts; then in nearly all cases dealation takes place.

With two species, however, the wings of the male are discarded, and the female flies off a short distance with him clinging tenaciously to her abdomen. In every species it is the female that directs all movements subsequent to these unconsummated nuptials. She leads the way by the shortest route to the ground, the male following her closely behind, and she then selects the site where the two burrow into the earth together.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, April 10th: E. J. Way, A.M.I.C.E., President, in the chair.—"*The status of an engineer*": J. B. **Roberts**. The author discussed the position and functions of engineering societies, and compared their activities with those of other professional societies. The mining regulations in force in the Union were commented on, and the requisite training for the engineer briefly considered.

Saturday, May 29th: E. J. Way, A.M.I.C.E., President, in the chair.—"*The Influence moisture in the air has on mine ventilation*": A. C. **Whittome.** The author emphasised the need of provision being made at every working place for a sufficient weight of oxygen to ensure an atmosphere suitable for breathing, and the necessity of attention being given to the modification of requisite volume involved in varying density and atmospheric humidity. It was suggested that medical investigation should be made into the effects on human beings of (*a*) the inhalation of varying volumes of air, consequent on change of pressure and temperature, in order that the requisite weight of oxygen shall reach the lungs; (*b*) the further modification of these volumes by the presence of a saturating amount of water vapour; and (*c*) the condensation in the lungs of water vapour from air at a temperature considerably higher than the body temperature.

Geological Society of South Africa.—Monday, April 19th: Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S., Vice-President, in the chair.—"*Notes on a graphic intergrowth of Diopside and Ilmenite from the Bembesi Diamond Field, Southern Rhodesia*": A. M. **McGregor.** A mixture such as that described is fairly common in the concentrates left by prospectors.—"*Notes on the occurrence of radioactive minerals in South Africa*": Dr. A. W. **Rogers.** The first group of radioactive minerals described from South Africa seems to have been the monazite and substances allied to euxenite and fergusonite from Embabaan in Swaziland, described by Dr. G. T. Prior. A mineral resembling the euxenite has been found in the course of geological survey work in Kenhardt. Radioactivity has also been found associated with specimens of columbite and tantalite from Little Namaqualand. Monazite, the commercial source of thorium and cerium, has been found in South Africa only in Swaziland and on the farm Houtenbek, 60 miles north-east of Pretoria.

THE PROBLEM OF HORSE-SICKNESS.

By Sir Arnold Theiler, K.C.M.G., D.Sc.

I need hardly apologise for introducing the subject of Horse-Sickness at present, seeing that the country has just passed through a very severe season, perhaps the most severe experienced within the past 25 or 30 years. All farmers long for a remedy, either in the shape of a cure or of a preventive. To find this remedy seems to solve the problem of horse-sickness. To show that this problem can be solved, and how it must be solved, is the object of this paper. Apart from its economic importance, the subject is of general biological interest. Our present knowledge concerning this disease allows us to draw certain conclusions which suggest the solution. This paper will indicate the lines for further investigation. In order to bring my points out clearly, it will be necessary to enter somewhat into the nature of the disease, and to show—(1) that it is caused by a micro-organism; (2) how this organism finds its entrance into the susceptible animal; (3) where it will probably be found under natural conditions (the reservoir of the virus). (4) The question of immunity, the result of our experience, will be dealt with rather extensively.

At the outset I must admit that many points are as yet of a hypothetical nature, but by analogy with other and similar diseases in which our facts are proved, we are justified in accepting the theory brought forward about horse-sickness as being well founded. The difficulties of bringing the actual proofs will be pointed out in the course of this paper.

1. The Cause of the Disease.

The micro-organism of horse-sickness belongs to the group of the so-called ultravisibles, whose size is beyond the resolving powers of our best microscopes. The dark-field illumination has not shown anything specific in those body liquids which we know contains the infection, neither has any attempt to cultivate it been successful, as, for instance, can be done with the filtrable virus of pleuro-pneumonia of cattle, where the micro-organisms show their presence as a cloudiness in a clear, suitable liquid medium. Since neither form nor shape of an organism can be detected, it is the common practice to speak of it as a virus. All horses which suffer from horse-sickness contain this virus in their blood, whether it be the Dunkop or the Dikkop form of the disease. By means of the injection of such blood into fresh, susceptible horses, the disease can be reproduced after an incubation period of three to thirty days in extreme cases. Whether Dunkop or Dikkop develops depends on the virus injected, and on the individuality of the horse itself. According to our experience the appearance of Dikkop is somehow

connected with the resistance of the horse. Although the impossibility of cultivating the virus in artificial media undoubtedly represents a great obstacle, it does not debar us from studying its character or from utilising it for the purpose of immunisation. It is a peculiar fact that horse-sickness virus retains its virulence in defibrinated blood for a considerable length of time, even four years or more, and frequently under the conditions of a polluted medium, the pollution giving rise to abscesses and gangrene in the injected horse before the disease develops. On the other hand, a virus may lose its virulence at any time, and particularly under the influence of some specific contamination not yet clearly elucidated. With proper care the virus will maintain a definite virulency for at least three years. Virus is only virulent as long as it is in a liquid medium. Of such a virus less than $\frac{1}{1000}$ of a cubic centimetre is required to produce the disease when injected into a susceptible horse, whereas when virus is given through the mouth comparatively large doses of even 100 or 150 c.c. or more are necessary. Taking this fact into consideration, it becomes evident that the froth discharged from the nostrils shortly before or after death, and which contains the virus, cannot be made responsible for the maintenance or the propagation of the disease outside an animal's body, neither the dead body itself.

2. The Transmission of the Disease.

The question arises here: In which way does virus gain access into the body of a susceptible horse? Here positive proofs are lacking, but facts so far collected allow of only one interpretation, *viz.*, that the disease is communicated to animals by means of winged insects. This view was in the first instance suggested by the fact that malarial fever in man and horse-sickness in equines are usually found under identical telluric and climatic conditions. It is true that in bad seasons horse-sickness appears before malaria, and has a wider range, spreading more rapidly and breaking out at higher altitudes. It was evident that the similarity was coincidental; it led to the conclusion that both diseases are propagated in an identical manner. Malaria in man is spread by mosquitoes of the genus *Anopheles*, and likewise horse-sickness must be spread by some insect, but not necessarily by the same species or even genus. Indeed, seeing that horse-sickness has a wider range, this fact should be interpreted to mean that a different insect was responsible. It is true that the analogy between the two diseases only holds as far as the transmission is concerned, and not to the cause. In the case of malarial fever the micro-organism is well known. It is a plasmodium, and its cycle within the hosts has been studied in detail. There are, however, other equally well-studied diseases in man carried by winged insects which are due to ultravisible micro-organisms, such as the yellow fever transmitted by the genus *Stegomya* and the Pappatacci fever trans-

mitted by the genus *Phlebotomus*. The experience that the exclusion of winged insects from a stable excludes horse-sickness must be regarded as a support of the theory. Experiments to this effect were carried out many years ago. Onderstepoort has been renowned for horse-sickness for many years past, and this was the deciding factor in the selection of the place. The laboratory has its stables so built that they can be made insect-proof, and during the horse-sickness season, when the horses are stabled, and no other precautions were taken, no cases of spontaneous horse-sickness have occurred. Nevertheless, the direct proof of transmission as it was forthcoming in the case of malaria, or in the case of the tick-borne diseases, is lacking. We do not know which genus of insects has to be made responsible. Persistent attempts to find this genus have been carried out ever since we occupied the place in 1908. Blood-sucking insects of nocturnal prevalence were trapped and collected. This was done by means of so-called "mosquito traps," *viz.*, small houses with sufficient room to hold a horse, open to the access of blood-sucking insects. A horse was placed in these houses during the night, and next morning a collection was made of the insects, principally blood-gorged mosquitoes, that were found on the ceiling and walls. This collection was carried out through a number of years, and it enabled us to find out which mosquitoes were most prevalent during the horse-sickness season.

The collections were submitted to Professor Theobald, the well-known authority on mosquitoes. He identified the species and described the new ones. In the second report on the mosquitoes of the Transvaal, published in the second report of the Director of Veterinary Research, he enumerates the species found in the Transvaal, a total number of 52. Of these, 46 species and some varieties were found at Onderstepoort, *viz.*, of the sub-family Anophælinæ: Genus—*Myzomia, Pyrotophorus, Cellia, Myzorhynchus, Nyssorhynchus*; of the sub-family Cullicinæ: Genus—*Mucidus, Stegomyia, Scutomyia, Pseudohowardina, Theobaldia, Culex, Banksenella, Chrysosonops, Taeniorhynchus, Pseudotæniorhynchus*; of the sub-family Uranotæninæ: Genus—*Uranotænia, Grabhamia*; of the sub-family Ædinæ: Genus—*Mansonia*.

In the same traps were also caught other biting nematocerous flies, *viz.*, of the genus *Culicoides*, the species *Culicoides milnei* Austen, and of the genus *Phlebotomus*, an undescribed new species, also a simulium of a new species.

The latest experiments undertaken with mosquitoes can be grouped into three classes.

The first series were carried out with the mosquitoes collected in the trap-boxes in the season 1913-14 between the 3rd December, 1913, and the 2nd May, 1914. They were released in an insect-proof box, built for this purpose, and containing a susceptible horse.

The following species were used:—*Culex pallidopunctata, Culex transvaalensis, Culex theileri, Banksenella luteolateralis.*

Pyretophorus aureosquamiger, Cellia squamosa, Myzorhynchus mauritianus, Grabhamia caballa, Culex onderstepoortensis, Nyssorhynchus pretoriensis, Stemgomyia argenteopunctata, Nyzorhynchus pretoriensis, var. *rufipes, Pyretophorus costalis, Myzomyia funesta.*

Some of these species were represented by only a few numbers, whilst others were numerous. The sum total so collected and let loose amounted to 461 individuals. In no instance was the disease transmitted.

The second series of experiments were carried out with the engorged mosquitoes collected in boxes which contained horses suffering from horse-sickness. They were then liberated in an insect-proof box containing a susceptible horse.

1. Of an undescribed *Culicoides* species were liberated in two boxes—in the first, a total number of 144 females from the 22nd March to 29th March, 1915; in the second one, 150 females between the 26th March and 31st March, 1915.

2. *Myzorhynchus mauritianus*: 31 engorged females were liberated between 17th March to 17th April, 1915.

3. *Myssorhynchus pretoriensis*: 25 engorged females were liberated between 15th March to 14th April, 1915.

4. *Nyzorrhynchus pretoriensis,* var. *rufipes*: 10 females were liberated between 27th March to 6th April, 1915.

5. *Cellia squamosa*: 42 engorged females were liberated from 15th March to 14th April, 1915.

6. *Pyretophorus aureosquamiger*: 3 engorged females were liberated from 31st March to 8th April, 1915.

7. *Banksinella luteolateralis*: 6 engorged females were liberated from 23rd March to 2nd April, 1915.

8. *Pyretophorus costalis*: 4 engorged females were liberated on 31st March, 1915.

In the third series of experiments the mosquitoes, caught engorged in traps containing a horse suffering from horse-sickness, were kept in wide glass cylinders closed on both ends with muslin. These cylinders were pressed against the skin of the suceptible horse, when the mosquitoes would sometimes feed. The mosquitoes were fed on susceptible horses at intervals of two to five days. The following species were selected, being the most commonly found: — *Pyretophorus costalis, Cellia squamosa, Myzorhynchus mauritianus,* and *Culex transvaalensis.*

These experiments were all under the care of Mr. Bedford, the Entomologist of the Division.

It is regrettable that all efforts were negative. They can, however, not be interpreted as showing that the species concerned do not transmit the disease. The failures are, in our opinion, due to a number of circumstances—*viz.*, the difficulty of keeping mosquitoes alive in an insect-proof loose-box together with a horse for a sufficiently long time, or even in a glass cylinder when feeding them individually. It is true some mosquitoes did live in captivity, but it must be remembered, in analogy to

malarial fever and yellow fever in many, that not all mosquitoes become infected.

By analogy with the fly-transmitted trypanosome diseases, a direct transmission of the disease by a winged insect is feasible, in which case a definite host would not even be required. If the transmission is effected by the same adult insect which sucks the blood, then the proof will be forthcoming one day. Should, however, the virus go through the progeny of the insects, as is the case in the tick-transmitted diseases, then the question becomes more difficult, since it is very difficult or impossible to breed some species (in particular of the sub-family Anophelinæ) in captivity. Notwithstanding our failures, we are so convinced of the correctness of the insect theory, that we feel sure that one day the exact proof will be forthcoming.

3. The Virus Reservoir.

The third question to be answered is: Where does the insect host obtain its infection? Once the horse-sickness season has started, every equine suffering from the disease will in turn infect the sucking insects. It is an experimentally well-established fact that, besides horses and mules, donkeys also contract the disease, but seldom die from it. It has also been experimentally proved that dogs can comparatively easily be infected with horse-sickness, either by injection with virus, or by feeding on carcases of horses that died from the disease. In our experiments on 54 dogs utilised for virus, nine died of the disease and 30 showed symptoms and recovered. It is noteworthy that we succeeded in transmitting the disease in dogs through 49 generations, and that, notwithstanding the adaption to the canine, the virulency in no way abated for the equine. Angora goats occasionally develop a typical fever to the injection of virus, and blood obtained during the reaction proved to be virulent for dogs. A curious fact in connection herewith was observed. The blood of the injected goat would prove to be infective for a dog and for a goat, but not for a horse, and only the blood of the dog would serve again as a virus for the horse. This transmission was, however, only possible for a few generations. It is likely that other animals as well are susceptible to horse-sickness, and serve as carriers of the virus. We tried sheep and cattle, but failed. It is an important fact that the immune animal no longer contains the virus in its circulatory blood. All attempts to this effect have failed; once the horse has recovered, the blood is no longer infective. The same holds good as far as dogs and goats are concerned. From an enzootological point of view, and in analogy to other diseases, we require an animal from which the insect obtains its infection as a virus-carrier other than those mentioned. To demonstrate this, I wish to mention that horse-sickness exists in localities where, perhaps on account of horse-sickness, there are no equines, and for various reasons there are no other domesticated animals, and in which localities the disease can be contracted at almost

any time of the year, although more at certain seasons than at others. In the case of the tsetse-fly disease, the game acts as virus-carrier, or as a virus reservoir; in the case of piroplasmoses, the recovered animal, cattle or horse, does. The reservoir for horse-sickness is not known. The analogy is, however, not a complete one. The blood of trypanosome immune game and that of piroplasms immune animals, is infective when injected into suitable suceptible animals; that of immune horses recovered from horse-sickness, however, is not. Perhaps this could be explained by accepting that the virus only becomes virulent after it has passed through the insect, similar to the observation, made in East Coast fever, that blood of an ox suffering from East Coast fever can be safely injected into a susceptible animal; the group of the brown tick, however, transmitting the disease promptly. But here also the simile is not quite analogous; the immune East Coast fever ox no longer acts as a reservoir. The experiments explained in connection with goat and dog blood indicate that the virus can be present in one animal (goat) without being infective for the horse, but becomes so as soon as it has passed through a second animal (the dog). If it could be shown that a winged insect becomes infected on the reacting goat, most discrepancies would disappear.

Quite a number of inoculation experiments were undertaken to find this reservoir. It is a fact that many birds live or perch near rivers during the night, and many of them are infected with bird malaria (*Proteosoma*), which is transmitted by Culicidæ, a sure indication that they must be bitten by mosquitoes.

A bird might act as reservoir. During the horse-sickness season we shot systematically a number of birds along the Aapies River, and their blood was injected into susceptible horses. There were a total number of 137 injections, for which purpose the blood of 27 birds was used, *viz.*:—

Elanus cœruleus (black-shouldered kite).
Cerchneis naumanni (lesser kestrel).
Cerchneis rupicoloides (larger kestrel).
Buteo desertorum (steppe buzzard).
Buteo jackal (jackal buzzard).
Scopus umbretta (hammerkop).
Centropus senegalensis (lark-heeled cuckoo).
Circus pygargus (Montague's harrier).
Ardea melanocephala (black-headed heron).
Ardea purpura (purple heron).
Turtur senegalensis (laughing dove).
Columba phæonota (speckled pigeon).
Œna capensis (Namaqua dove).
Asio nisuella (marsh owl).
Strix capensis (grass owl).
Bubo maculosus (spotted eagle owl).

Lanius collaris (common fiskal shrike).
Crex crex (European corn crake).
Coliopasser procne (long-tailed widow bird).
Ciconia ciconia (white stork).
Herodias garzetta (little egret).
Stephanibyx coronatus (crowned bapwing).
Astur poluzonoides (a hawk).
Serpentarius secretarius (secretary bird).
Corvus scapulatus (pied crow).
Micronisus gabar (goshawk).

And a wild duck, species not identified.

Of wild mammals the blood of the following species was injected:—Jackal, hedgehog, rock rabbit, bats, striped mice, grey mice, field bats, zebra and yellow meercat. A total number of 67 injections were made. Of reptiles, the blood of the common iguanas and water tortoises was utilised. A total number of eight injections was made. Of Amphibia, the blood of frogs (a non-determined species) was injected. Twelve injections were made. In addition to these, the blood of domesticated ruminants, born and kept on a horse-sickness farm, was injected, *viz.*, of cattle, Africander goats, sheep and lambs, and dogs, also blood of salted horses and mules running on the farm (Onderstepoort) for a number of years. The blood of four natives, who volunteered to a tapping, was also utilised.

Taking into consideration the difficulty of tracing the reservoir, the negative results cannot be taken as final. The geographical distribution of both disease and certain animals could give a clue as to the direction in which further experiment should be undertaken. It is known, for instance, that horse-sickness does not occur in Western Africa from north of Angola as far as North-East Africa, but is present right through Central and East Africa to the shores of the Red Sea.

4. Immunity.

From a practical point of view, the question of immunity is of great importance. Immunity is only observed in diseases caused by certain groups of micro-organisms, and may be of a shorter or longer duration. The practical side of immunity is its application for the protection of susceptible animals. It is necessary to ascertain first under what conditions and to what extent immunity is found in horses that have recovered from horse-sickness.

It is well known that equines can recover from horse-sickness, from either the Dikkop or Dunkop form: such horses or mules are known under the term of "salted."

The mere fact that such salted horses are of greater value, and that a guarantee of "salting" is asked for by buyers and given by sellers, indicates that such horses are thought to be

not susceptible, or, at least, less susceptible than horses not immune to the disease.

It is, however, on the other hand, an equally well-known fact that salted horses may again sicken from horse-sickness (which fact is expressed by the term *aanmaaning* or "relapse"). This relapse is generally of a less severe nature than the primary attack, many horses recovering again. Furthermore, the experience has been made that salted horses can die of the disease, and that they die more in some localities and in some seasons than in others.

The term *aanmaaning* or "relapse" is open to misinterpretation. It is usually explained by analogy to the experience in malarial fever in man. There is a difference. In malarial fever in man the germs are still present in the apparently healthy man, and develop again under some external influence such as cold, change of climate, etc., and at any time of the year, whereas in horse-sickness *aanmaanings* are only noted during the horse-sickness season. Indeed, it is not a relapse in the true sense of the word; it is a new infection. This has experimentally been proved.

As a result of our investigations into immunity, I have been able to devise a means of protection by a combination of serum and virus injections, which will be explained later. A great number of mules and a number of horses have been immunised and subjected to tests on their immunity. In this way definite conclusions were arrived at as to the extent to which immunity is conveyed by an attack of horse-sickness. For our initial experiments we used a virus obtained from a horse in Pretoria. We soon found that some of the mules exposed in various parts of the country again contracted the disease—it is true only to a small extent; some recovered, whilst others died. Material was obtained from these cases of break-down, and used for further investigations. With the object of giving the salient facts, without going too much into detail, I have selected the two chief viruses that have been used throughout my investigations, being the Pretoria ordinary strain referred to above, and the Tzaneen strain obtained from the first authenticated case of a breakdown in an immunised mule. The experiments relate to horses only. The following figures have been compiled from the results of a number of experiments in which the immunity in particular was studied from the injection of the two viruses. A total number of 1,078 animals come into consideration, of which 327 horses were first injected with ordinary virus, and 751 with Tzaneen virus. With the object of facilitating comparisons, percentages have been used throughout:—

A. Result of Injections.

	Ordinary Virus		Tzaneen Virus	
	per cent.		per cent.	
Not reacting to the injection (non-reactors ..	20		28	
Reacting with a Dunkop to the injection (Dunkop recoveries)	18	36	24	43
Reacting with a Dikkop to the injection (Dikkop recoveries)	18		19	
Deaths from Dunkop	26	44	10	29
,, ,, Dikkop	18		19	

Abstract.

Total survivors from injection	56	71
Dunkop form produced in	44	34
Dikkop	36	38

It is thus quite clear that, in the first place, a certain percentage of animals do not react, and that this figure varies with different viruses. We can, therefore, speak of weak and strong viruses, Tzaneen being a weak virus, and ordinary a strong virus. This conclusion is also supported by the percentage of mortality caused by these viruses, the weak one killing 29 per cent., and the strong one 44 per cent. This point in itself is particularly interesting, seeing the Tzaneen strain broke down the immunity given by the ordinary virus in the case of the mule just referred to, and in many others. The failure of a certain percentage of animals to react can be explained in two ways—firstly, a naturally acquired immunity to the virus, and secondly, their individuality. It can be readily understood that, in experimenting on so many animals collected from all parts of the Union, we must expect to come in contact with horses that have salted as a result of natural infection on the veld, and that their immunity is sufficiently strong to afford protection against one injection of virus; there may also be horses not susceptible to horse-sickness.

A discussion on the question of the individuality of an animal would take up too much of our time, and is rather outside of the scope of this paper, but experiments have definitely proved that it is a factor which cannot be ignored. It will be sufficient to say now, that although a horse may not react to a virus at one moment, yet when re-injected with the same virus at a later date, death may result. This is particularly the case with an attenuated virus, as, for instance, the Tzaneen virus.

The second point of interest that arises from the above table is in connection with the percentage of cases of Dikkop produced by the injection of virus as compared with the cases of Dunkop. With ordinary virus more horses die of Dunkop than of Dikkop. With the Tzaneen virus the reverse is the case. I mentioned before that the appearance of

Dikkop is connected both with virus and the individuality of the horse. With a very virulent virus more Dunkop will result; the animal has less time to put up a defence. With a weaker virus a Dikkop appears; the incubation period being longer, the animal can put up a defence.

B. RESULT OF TESTS.—The majority of the horses that survived the injections just referred to were later tested on their immunity, using both the same virus as that utilised for injection, and, in addition, fresh viruses. These latter viruses were obtained in many ways: some from horses or mules that contracted horse-sickness or died from horse-sickness in various parts of South Africa, others from immunised mules that died of breakdowns or showed relapses, and others, again, from naturally salted horses and mules that showed *aanmaanings* or died. Finally, compound viruses were obtained either by mixing two or more viruses or by injecting various horses with different strains, thus gradually amalgamating the viruses until all were present in one horse.

The actual number of tests carried out on each horse, and the kind and quantity of virus used, varied to a considerable extent. Some horses were only tested by the injection of 1 or 2 c.c. virus, whereas others received as many as ten or twelve different injections, of which perhaps three or four consisted of 2 or 5 c.c. virus each, whilst the remaining eight or nine injections consisted of 10,000 c.c. each (hyperimmunisation). In other words, no horses received as a test less than an amount sufficient to kill over 1,000 horses, whereas others received sufficient to kill over 10 million animals. Out of the original number of 1,078 horses used for injection, 670 were subsequently tested, and the following figures represent some 1,738 tests, an average of roughly three tests per horse. The individual figures are: 1,187 tests carried out on the 494 horses that survived the injection of Tzaneen virus, and 551 tests on the 176 horses that survived the original injection of ordinary virus.

(1) *Animals that Failed to React to the Original Injection.*

	Immune to Ordinary per cent.		or	Tzaneen Virus per cent.	
Again failed to react to any tests	20			11	
Showed one or more Dunkop reactions and recovered	9	24		17	33
,, ,, Dikkop ,, ,, ,,	15			16	
,, ,, reactions and finally died of Dunkop	48	56		44	56
,, ,, ,, ,, ,, Dikkop	8			12	

Abstract.

Total survivors from tests	44	44
Dunkop form produced by tests in	57	61
Dikkop ,, ,, ,, ...	23	28

(2) *Animals that Showed a Dunkop Reaction to the Original Injection.*

	Immune to Ordinary per cent.		or	Tzaneen Virus per cent.	
Now failed to react to any tests	71			18	
Showed one (a second) or more Dunkop reactions and recovered	4	4		19	30
Showed one or more Dikkop reactions and recovered	Nil			11	
Showed one or more reactions and finally died of Dunkop	25	25		45	52
,, ,, ,, ,, ,, Dikkop	Nil			7	

Abstract.

Total survivors from tests	75	46
Dunkop form produced by tests in	29	66
Dikkop ,, ,, ,, ...	Nil	18

(3) *Animals that showed a Dikkop Reaction to the Original Injection.*

	Immune to Ordinary per cent.		or	Tzaneen Virus per cent.	
Now failed to react to any tests	77			21	
Showed one or more Dunkop reactions and recovered	Nil	6		43	54
Showed one (a second) or more Dikkop reactions and recovered	6			11	
Showed one or more reactions and finally died of Dunkop	15	17		18	25
,, ,, ,, ,, ,, Dikkop	2			11	

Abstract.

Total survivors from tests	83	75
Dunkop form produced by tests in	15	61
Dikkop ,, ,, ,, ...	8	18

(4) *Total Number of Animals that Reacted (both forms) to the Original Injection.*

	Immune to Ordinary per cent.	or	Tzaneen Virus per cent.
Now failed to react to any tests	74		19
Showed one or more reactions (either form) and recovered	5		42
,, ,, ,, ,, ,, ,, died	21		39

In considering these results, it will be noted:

1. That there is still a certain percentage of horses that completely fail to react to all injections. (By failing to react, I mean that no febrile reaction occurs, and the horse does not show any clinical symptoms of horse-sickness.) In the case of ordinary virus, this percentage is 20 per cent.—that is to say, 4 per cent. of the original number of horses completely resisted

the injection and tests. With Tzaneen virus the percentage of 11 corresponds to 3 per cent. of the original number; accordingly it can safely be concluded that out of every 100 horses taken at random, about three or four will resist all injections of virus, and can be considered as completely immune.

2. The fact that a horse does not react to one injection does not necessarily mean that it possesses any immunity; in fact, it can be seen from the figures given that the disease was contracted by 80 per cent of animals in the case of ordinary virus, and by 89 per cent. of animals in the case of Tzaneen virus, of which 56 per cent. died in both instances. In other words, out of 100 horses that do not react to one injection, 56 will die when tested later.

3. Of the horses that reacted to the original injection, considering both Dunkop and Dikkop forms together, a far better immunity was given by ordinary virus, the survivors amounting to 79 per cent. as compared with 61 per cent. from Tzaneen virus. It is, however, evident that even in the case of the strong virus (ordinary), a reaction does not constitute immunity to subsequent injections. That is to say, out of 100 horses that recover from horse-sickness, and which are considered "salted," anything from 26 to 81 can be expected to contract the so-called "relapse" or *aanmaanings*, the number varying according to the strength of the virus, conferring what I may call the "ground" immunity.

4. On comparing the results of the tests on the horses that obtained their ground immunity as a result of a Dunkop reaction with those that obtained it from a Dikkop reaction, the advantage of a Dikkop immunity is at once noticed. In the case of ordinary virus only 17 per cent. of the Dikkop reactors died on test, as compared with 25 per cent. of the Dunkop reactors, whilst with Tzaneen virus the difference is even more marked, the respective figures being 25 per cent. as compared with 52 per cent. From a practical point of view, therefore, a horse that has "salted" from the Dikkop form of horse-sickness has a better chance of resisting later infections than a horse that salts from the Dunkop form. Recovery from one attack of Dikkop is, however, not a guarantee against later attacks of the same form. Amongst the horses referred to, 15 per cent. of Dikkop reactors contracted the same form for the second time, 7 per cent. died at the second attack, whilst 1.5 per cent. contracted it three times, of which 0.5 per cent. died at the third attack.

5. I have not given any special statistics relating to the "breaking power" of any particular virus, and have only mentioned the one case of the breaking power of Tzaneen virus on the mule that salted to ordinary virus. This point was also experimentally investigated, and whilst it held good that Tzaneen virus could break the immunity given by ordinary virus, yet the reverse also applied when ordinary virus broke the immunity

conferred by Tzaneen virus. In fact, after we had collected all the different strains of virus from all parts of the country, we found that practically any virus could break down the immunity given by any other virus. Accordingly, although ordinary virus can be spoken of as a strong virus, yet it has practically no greater "breaking power" than any other virus.

6. Some special consideration merits the degree of immunity apart from the quality. A horse that reacted to the minimum test dose of at least 2,000 fatal doses of ordinary virus cannot be infected with horse-sickness if we use the same virus as a dose of a million times or even more. The horse will not show the slightest reaction. It produces, nevertheless, as a response to this injection, anti-bodies. This is the principles of hyper-immunisation. Notwithstanding the presence of anti-bodies in the blood-stream, the horse can contract the disease again, when a virus of a higher generation of the same strain is used, and likewise, such horses exposed to natural conditions may contract the disease as well. For protection, therefore, the degree of immunity does not seem to come into consideration, but the quality, a point which has already been brought out.

The Solution of the Problem is the Discovery of a Cure or a Method of Prevention.

I shall deal with the cure first. Under natural conditions about 90 per cent. of all sick horses die. The disease is usually only detected in its final stage, or at a time when the destiny of the horse is already settled one way or another. It is an old maxim in medicine, "To cure the disease, remove the cause." The removal of the cause means in all infectious diseases the destruction of the parasites. This is done by so-called specifics. Only for a few organisms of the protozooic kingdom are specifics known, *viz.*, the plasmodium of the malarial fevers, which in the merozootic stage can be attacked by quinine; the group of Babesia, which yield to the aniline dye trypan-blue; and the spirochætes, which are susceptible to organic arsenic compounds, in particular salvarsan, as are also some of the trypanosomes. It was the merit of Ehrlich to have shown how the action of these drugs can be explained. Based on his lateral chain theory, he assumes that in the micro-organisms are certain chemo-receptors, which fix the chemical compound, and through the bridge so formed acts the toxophoric group of the compounds, *viz.*, the arsenic. Most of the chemical compounds which could be utilised as parasiticides act principally on the cells of the body of the host; they are, in Ehrlich's language, organotropic, and hence damage the host. To find "parasitiotropic" drugs is the aim of modern chemotherapy. Thanks to the assistance of Ehrlich, I have been able to try quite a number of these drugs on horse-sickness, in particular, arsenophenylglycin, salvarsan, novoflavin, and some aniline dyes. I am

sorry to say that in none of these modern drugs has a cure yet been found.

Another method of attacking the causal organism in the system is by means of the serum therapy. Immunity in an infectious disease is usually accompanied by the production of specific anti-bodies usually found in the blood-stream. By means of hyperimmunisation an increase of immune bodies in the blood-stream can be effected. They are present in the serum withdrawn from such an animal, which, properly preserved, represents the remedy. These anti-bodies are either anti-toxic—*viz.*, they neutralise the toxin produced by the organism—or anti-infectious—*viz.*, they kill the organisms. Also in horse-sickness we can produce an anti-serum, notwithstanding that the micro-organisms is ultravisible and not cultivable. It is done simply by transfusing the blood of a sick animal which contains the virus into an immune animal, and in due time, about 14 days later, the serum of the immune animal is ready for use. That such a serum is powerful is shown by the fact that the addition of serum to a quantity of corresponding virus renders this virus harmless; it is also capable of arresting the evolution of horse-sickness in a horse which has been injected with a strain of less virulency than that which served to produce the serum, and is even so powerful as to turn a reaction produced by such an attenuated virus to a recovery in a great number of cases. The activity of the serum on the fully-developed disease, as recognised by the layman, even when due to a weak virus, is almost nil. The lesions produced by the horse-sickness organism seems to be irreparable after they have reached a certain stage. Serum is, therefore, of but little use from a curative point of view. An attempt for the solution of the problem must be directed towards the prevention of the disease. This can be undertaken in two different ways. The one, the radical one, which goes at the root of the evil, means the eradication of the disease; the other one, of a temporary character, means the protection of the animals against the attacking transmitting hosts, or by means of immunity against the causal organisms injected by the transmitting hosts.

The eradication of the disease would be the ideal solution of the problem. Can it be achieved?

In the chain of events which lead to horse-sickness there are two links, which, when they could be broken, would lead to this great object. The one is the destruction of the virus reservoir (the virus carrier), the other of the virus transmitting insect. Since the virus carrier is not as yet known, further suggestions are out of place. The question is nevertheless of theoretical importance. The destruction of the transmitting agency would be possible, although we do not as yet know it exactly. In the past we have not pressed home this point as much as it deserved, simply because we did not, and do not, know the actual insect. We do not know its whereabouts, its

breeding-places, etc. We assume it is a mosquito or an insect with similar habits. The destruction of all mosquito-life would, in all probability, remove the disease. This is an undertaking which might be carried out in definite localities, and should be encouraged. It would, however, be an undertaking of enormous magnitude if undertaken over a large area. That is can be done has been shown by the anti-malaria and anti-yellow fever campaigns in the various parts of the world, the striking example of some magnitude being the sanitation of the Panama Canal zone.

There remains, therefore, at present the alternative, *viz.*, the protection of the individual equines. The susceptible equines must be considered from two points of view, *viz.*, whether they can be stabled during the dangerous season, or whether they have to be kept in the open. Stabled animals can be protected against the disease effectively, provided the stable is insect proof. The efficacy of this method cannot be doubted; where it failed, the cause of failure can be found. Unfortunately stabling is not always applicable; horses and mules must be used at any time, and frequently during the night. Under such conditions a protection applied to the skin comes into consideration. For the past 15 years the Veterinary Division has advocated this method, and has recommended the use of paraffin, or a mixture of paraffin and oil, supplied as a simple and convenient remedy. The use of paraffin and oil suggested itself from the observation made during the war. Horses badly suffering from mange were treated with a mixture of paraffin, linseed oil, and sulphur, and were allowed to run during the horse-sickness season. It was a striking fact that horses so treated did not contract horse-sickness. Paraffin has since for many years been made use of by Transvaal farmers. The method is not infallible, and could be improved. Antiseptics of the tar-derivation group have been tried as well, and are used by many, and in particular as a spray, with different results. Where a great number of horses are concerned, the application of similarly acting remedies in a convenient and economic manner becomes necessary. Since the introduction of the dipping tank, the tank suggested itself for this purpose. Our first experiment, undertaken in 1912 in Natal, with the usual arsenical dipping fluid, was, however, not encouraging. Of six horses which were regularly dipped at weekly intervals, four contracted horse-sickness and died. There was a doubt about the diagnosis of the disease, but it was supported by subsequent tests. In the pamphlet published in 1912, dealing with the result of dipping cattle in Natal, reference is made to the results obtained with dipping horses exposed to horse-sickness. They were indifferent, and not conclusive. Very encouaging results were obtained by the De Beers Company, who, during the last year, dipped their horses and mules at regular intervals in a cattle dip to which was added three gallons of linseed oil and two gallons of paraffin oil for every 300 horses

going through the dip. The losses were only 37 horses out of a total number of 1,066. This result is better than we can expect to obtain from preventative inoculation. This observation deserves full attention. Experiments to obtain a better protective substance to be applied to the skins of horses by means of spraying or dipping have been for some time, and are still, undertaken by the Division.

The prevention of the disease by rendering the exposed animals immune would undoubtedly represent the most economic way, and would meet all requirements, provided a simple method could be found, which could be applied with none or but little risk, and which would give the maximum of immunity. The method which conforms to these requirements does not exist; the inoculation of mules, as introduced about ten years ago, seems nevertheless to answer most practical requirements. This method consists in a simultaneous inoculation of protective serum and virus under the skin, the virus producing the disease, the serum modifying it so that recovery ensues. The virus utilised is the Pretoria strain, which, as previously has been shown, gives a good immunity. Breakdowns and deaths due to natural exposure do occur, and vary in different seasons. A mortality of 5 to 6 per cent. is probably the average loss.

For horses we have not yet been able to overcome all difficulties, and they are more numerous than we anticipated. A simple method, as in the case of mules, seems to be excluded.

The injection of serum simultaneously with the adequate Pretoria or ordinary virus is followed by heavy mortality. The factor which assists the mule to pass through the disease is absent in the horse. It is probably the factor inherited from the ass. A weak virus, on the other hand, when injected simultaneously with the serum, is acted upon by the serum, and no disease develops and no immunity ensues. Of the Tzaneen strain we possess two varieties, a virulent one and an attenuated one. Both qualities have been obtained by the same process, *viz.*, by passage from one animal to another. It is difficult to say what is the modifying agency which converts the virus into either a weak or a strong virulency. Experience has shown that it is the horse or mule in which the virus develops which supplies it. It is probably a quality of all viruses to undergo these modifications. The virulency of the same generation, obtained from different animals, varies according to the animal from which it is obtained. No definite law can be laid down. It is a matter of experimenting to find a virus of suitable virulency. In the case of Tzaneen strain a lower generation will break the immunity conveyed by a higher generation, and in the case of the ordinary strain the higher generation will break that conveyed by a lower. Ordinary virus through a great number of generations has become very exalted in its virulency. We immunise at present horses by injecting first attenuated Tzaneen virus—we may call it the virus-vaccine—then serum calculated

according to the body-weight, injected some days subsequently. The most suitable period proved to be the sixth and tenth day. The serum checks the development of the virus and modifies the disease. In our experiments with a selected virus and serum, we were able to obtain in several instances 100 per cent. recoveries, and this on a fairly large number of animals. The problem of successful inoculation could thus be solved, but, alas! not that of successful immunisation. Indeed, the immunity is not a complete one, not even in horses, which passed through the Dikkop form of horse-sickness due to the inoculation. This fact has nothing surprising in the light of previous statements. For some time means were devised to overcome the difficulty. In a horse successfully inoculated with a series of different viruses the chances of breakdown are reduced in proportion to the number and quality of viruses injected. Based on the observation shown before that the ordinary virus gave a better immunity than any other, experiments were undertaken to incorporate this virus into the process of inoculation. It was found that, simultaneously with the second dose of serum, the injection of ordinary virus could be undertaken with a certain amount of risk, varying in the various experiments. The immunity so obtained was better than that obtained with one virus alone, but still not so good as in mules immunised with the same virus. It is possible that under the influence of the active immunity produced by the first Tzaneen virus injection, together with the passive immunity of the two subsequent serum injections, the development of the ordinary virus is completely arrested in many horses injected, and hence the immunity not improved. That this must be so can be seen from subsequent tests with ordinary virus, when breakdowns are produced which no longer should occur. The superplanting of a second immunity on the first one offers, nevertheless, a good prospect for the practical solution. The experience of this year supports this: Of 49 horses possessing an immunity to the highest generation of ordinary virus exposed to the very severe natural conditions prevalent this year, 4 per cent. died. This is probably the optimum result we can expect, but it could only be obtained at the expense of a high mortality from immunisation. This latter difficulty has not yet been overcome. It should be clear that in horse-sickness we cannot expect an absolute immunity, *viz.*, an immunity which protects all horses under all conditions against the disease. The protective inoculation has therefore its limits, but it has also, as it stands to-day, its limits from a technical point of view. Three inoculations are required to convey and modify the two necessary attacks of horse-sickness, and a period of four weeks to recover. Furthermore, only a limited quantity of serum can be made under present conditions. It is evident that the protective inoculation cannot yet be looked upon to be the final solution of the problem, even if we are able to pass all horses through an attack of the disease, and we can

safely say that most likely it cannot be solved in this way alone, simply beceause the immunity obtained is not a reliable one. Immunisation, therefore, is only a temporary remedy, but it will have its practical usefulness as long as the disease is prevalent in South Africa. On the other hand, it has also its drawbacks. The immunity of the salted horse lulls the proprietor into a false security, and he takes risks which he otherwise would not take, frequently with the result that the immunity breaks down.

CONCLUSION.

The solution of the problem of horse-sickness for the time being lies in the protection of animals against infection. The selection of the methods to obtain this end depends entirely upon the number of animals to be protected, upon the conditions under which they are held and exposed to infection. That horse-sickness can be prevented should be clear, but success entirely depends upon the energy of the individual who applies the methods.

The final solution of the problem is the eradication of the disease from South Africa. That even this is feasible, and will one day be possible, should be the conclusion that can be drawn from this paper.

MESEMBRIANTHEMUM TORTUOSUM.—Under the heading "Channa, a delicacy of the Hottentots," the *Journal of the Chemical Society** quotes some results of work done by Hartwich and Zwicky on *Mesembrianthemum tortuosum* L. and *M. expansum* L., the former of which is commonly known as *Hottentot. kouwgoed,* the name *Ganna* being applied not to that genus at all, but to *Salsola aphylla*. The active constituent was found to be the alkaloid mesembrine, $C_{16}H_{19}O_4N$, of which the leaves contain .3 per cent. and the stems and roots .86 per cent. The alkaloid dissolves freely in chloroform, alcohol, or acetone, sparingly in ether, water or alkalies, and very sparingly in light petroleum or benzene. With vanadic sulphuric acid it gives a brownish-red solution, a green tint developing on warming, and becoming bright green after 24 hours. Mesembrine is unsaturated, acts as a phenol, and has an action somewhat resembling, but distinct from that of cocaine. Every branch of the mesembrianthemum family includes species which do and which do not contain this alkaloid. A wax containing 25 per cent. of saponifiable material was found in the epidermis of the leaves. The unsaponifiable part is a mixture of mesembrene $C_{28}H_{56}$, and mesembrol, $C_{31}H_{64}O$, or $C_{30}H_{62}O$.

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FIRE-RESISTING MATERIALS IN BUILDING CONSTRUCTION.

By Arthur Henry Reid, F.R.I.B.A., F.R.San.I., F.R.S.A.

The increasing congestion of habitations in towns renders the study of materials used in building construction one of vital interest to the community. The following notes, though gathered into a small compass, are the results of investigations made during the past decade, and in this record I have endeavoured to combine some indication of underlying principles with suggestions regarding problems that still await solution. Further research may yet discover materials that are suitable for the purposes of insulation and protection, which may combine easy manipulation with moderation in cost. The knowledge we possess is not altogether satisfactory in many respects, and the subject is one worthy of our widest and most careful consideration.

The author, in submitting this paper, wishes it to be understood that its scope is confined to " Materials " only, and is not intended to cover the constructional features of fire resisting buildings. It may be fairly claimed that no construction is absolutely fireproof, and that even iron and masonry, in their crude form, could with propriety be designated as " slow burning." Steel has, in the process of manufacture, been smelted in a furnace which produced little greater heat than would some of our modern buildings with their contents when in a state of full combustion. It is, therefore, necessary to cover and protect steel units with non-combustible and non-conducting material to prevent exposure to fire and consequent expansion or distortion.

It is proposed to review the leading classes of material that are used in buildings, and to enumerate the peculiarities of each as well as the precautions that experience has shown to be necessary for their protection.

Steel.—Wrought and cast-iron may be regarded as practically obsolete for structural purposes, though both have the advantage, under certain circumstances, of being less liable to corrosion than steel.

Mild steel, containing a proper percentage of carbon, is produced by the Bessemer and other processes. In the former molten " pig " iron is blown through, the carbon and other elements burnt out, and then the desired proportions of carbon and manganese are added. Steel is about universally used for the purpose of reinforcement in fire-resisting construction, and ordinary " mild " steel is preferred of an ultimate tensile strength of, say, 64,000 lbs. (30 tons) per square inch. Mild steel that has been rolled possesses an ultimate strength of about 89,000 lbs. (40 tons) per square inch, but it has been found that

such material loses strength, when heated, more than mild steel, and is, therefore, not favoured for fire-resisting construction.

Reinforcement.—Various types of bars, expanded metal and wire mesh fabrics are used as reinforcement of concrete, and small members are generally favoured as they give a greater proportionate surface for adhesion, and are more easily manipulated. Each has its strong and weak points, according to the work allotted to it, which alone can be judged by the designer.

Structural Allocation of Materials.—Generally speaking, it is admitted that stone should be avoided where there is any chance of exposure to excessive temperature or flame. Sandstones, limestones, and granites are dangerous, as they crumble away or split into pieces if water is suddenly applied when they are subjected to continuous extreme heat. For this reason they should never be used for staircases or as piers to support superincumbent walls. Cast-iron, wrought iron, or steel, when exposed to heat, appear at first to increase slightly in tensile strength, but as the temperature rises their strength falls rapidly.

This is especially the case with wrought iron or steel, some descriptions of which may lose strength to the extent of 70 to 80 per cent. before a distinct red heat is reached. Cold water suddenly applied to cast-iron, when highly heated, may cause it to crack or fly to pieces. Wrought iron or steel, under similar circumstances, would become considerably twisted or distorted. Irregular heating, such as may take place when a stanchion is partly buried in a wall and one or more faces exposed to the heat, creates internal strains that tend to induce distortion or twisting, and the same applies to floor beams that are partly enclosed in concrete, and have their lower flange exposed.

The efficient protection of metal from excessive or irregular heating is therefore essential.

For the convenient allocation of fire-resisting or protective materials to the several constituent portions of a building, it will be well to sub-divide the same into sections, separating the horizontal from the vertical units. The former consist of floors, ceilings, roofs and staircases, and the latter of walls, piers, and partitions.

Floors.—Solid wood baulks, hollow terra-cotta slabs and reinforced concrete cast *in situ* are generally accepted as the most effective materials for the construction of fire-resisting floors, but the latter, on account of its cheapness, is generally adopted. The following remarks upon concrete will, of course, apply generally to piers and other horizontal and vertical units.

Fire-resisting concrete requires an aggregate of material that has already been burnt, such as broken brick, burnt ballast, pumice, furnace slag, clinker of a hard and weight-bearing structure, and metamorphic stone generally.

Concrete is, compartively speaking, strong in compression and weak in tension, the ratio of compressive to tensile strength being about as from 6 to 10 is to 1. Its lack of tensile strength

renders reinforcement necessary where tensile strain is applied. When properly embedded in suitable concrete, steel is protected against the destructive influences of damp and heat. Coke breeze and cinders are not favoured for reinforced work as the possible presence of sulphur would act deleteriously upon the steel.

Portland cement is universally adopted as the matrix of fire resisting concrete, and only very finely ground and medium setting cement should be used for the purpose.

The coefficients of expansion for concrete and steel being practically the same, a combination of these materials secures homogeneity, and ensures that the two materials will act together, and not throw undue stress upon either. This is most important, for otherwise a rise in temperature, say, by the application of fire, would cause the two materials to separate.

Success again depends largely upon the adhesion of the concrete to the steel, and this depends, to a great extent, upon the contraction that takes place during the "setting" of the concrete. An adhesive strength of 100 lbs. per square inch is generally recommended, though 250 lbs. at the age of one month is attainable with care. It may be interesting to note that slightly rusted steel bars give better adhesion than clean ones.

Painting or coating prevents adhesion, and is therefore to be avoided. Practical tests have proved that concrete, with the best aggregates and cement when mixed 4:2:1, possesses a comprehensive strength of about 1,800 lbs. per square inch at the age of one month, while broken stone concrete, mixed 6:3:1, should give a tensile strength of about 350 lbs. per square inch.

The effect of heat is to reduce the strength of concrete so that a varying factor of safety has to be decided upon.

Experiments made by Professor Woolson, in the United States of America, showed that concrete, with an aggregate of trap rock mixed 4:2:1, gave a compressive strength per square inch as follows:—

Unheated.	500°F.	750°F.	1,000°F.	1,250°F.	1,500°F.	2,000°F.
1,900 lb.	1,850 lb.	1,800 lb.	1,400 lb.	1,200 lb.	1,000 lb.	700 lb.

Four inch cubes were used in the tests.

Fire tests with floors of different types, as made by the British Fire Prevention Committee, have proved that, as far as the concrete itself is concerned, the following prevented the passage of fire when exposed to temperature varying from 1,800° F. to 2,000° F. for several hours:—

1. Coke breeze and Portland cement mixed 5:1 and 5″ thick.
2. Blast furnace slag, sand and cement, mixed 3:2:1 and 5½″ thick. Became red hot.
3. Broken brick, sand and cement, mixed 3:2:1 and 5½″ thick.
4. Broken granite, sand and cement, mixed 3:2:1 and 5½″ thick.

5. Burnt ballast and cement, mixed 5:1 and 5½″ thick.

6. Furnace clinker, sand and cement, mixed 3:2:1 and 5½″ thick. Became red hot.

7. Thames ballast, sand and cement, mixed 3:2:1 and 5½″ thick. Became red hot.

The general result was in favour of Nos. 1, 5 and 6, and details of the gauge of aggregates, quantity of water, and method of mixing and depositing can be ascertained by referring to the committee's literature and reports. It is thus evident that burnt aggregates should be used, and materials containing latent heat avoided.

The committee's experiments with timber gave the following results, though, of course, the varying bulk or dimensions of the specimens render them comparatively valueless.

Karri Wood: 2 hours' exposure—maximum temperature 1,800° F., charred depth ¾″.

Jarrah Wood: 2 hours' exposure—maximum temperature 2,000° F., charred depth ¾″.

Fir: 2 hours' exposure—maximum temperature 2,000° F., charred depth 2″.

Oak: 47 minutes' exposure of 2½″ boards in a horizontal position at a maximum temperature of 2,000° F., consumed them.

The Karri and Jarrah wood was probably specially selected for the tests.

Causes of Failure.—When not caused by earthquakes, explosions, lightning or other shocks, which may be classed as "unavoidable causes," failures are due to more or less "preventable causes," and, as a rule, can be attributed to carelessness or incompetence in the design or execution of the work.

Failures due to Materials.—Failures due to the careless selection or manipulation of *materials* are commonly found to come under one or other of the following heads:—

(*a*) The use of inferior, unaerated, damaged or too quick setting cement.

(*b*) The use of unsuitable or inferior aggregates, such, for instance, as contain only very coarse material, or have been insufficiently graded or carry too much sand or loam, or by the presence of free lime in the stone.

(*c*) The use of water containing clay or injurious chemical constituents. The use of too much or too little water in the process of mixing or the uneven application of same.

Failures due to other Causes.

(*d*) Carelessness in the proportioning or mixing of the aggregate with the cement.

(*e*) Disturbance of the concrete after the "setting" has progressed.

(*f*) By the remixing and use of old concrete after it has set.
(*g*) By excessive ramming or tamping or violent trowelling of the surface.
(*h*) By placing new concrete on old and dry work without first saturating and preparing the latter.
(*i*) By allowing the concrete to freeze or by depositing same in hot weather, which induces an initial "set" when mixing, which becomes broken in the process of deposition.
(*j*) The premature removal of "forms" or centres, or the insufficiency or careless arrangement of same or their supports.

Failures due to lack of Scientific Application.

(*k*) By errors in design or calculation.
(*l*) By the misplacement or omission of proper reinforcement.
(*m*) By inefficient supervision coupled with careless or incapable workmen.

It must be patent to anyone, versed in the principles of sound construction, that a concrete building is a monolith, and as such is subject to extreme strains in case of a conflagration, due to the expansion and subsequent contraction of its substance, or portions of same, which is accentuated by the application of cold water to its surface.

This operation inflicts a compound destructive factor in the possible disintegration of the protective covering of the reinforcement. The absolute necessity of laboratory tests and analyses of materials is an established fact that no designer is justified in overlooking when such structures are under consideration.

Ceilings.—Suspended or appended ceilings of incombustible material are valuable factors in the protection of wooden floor joists, and also of concrete floors. The types generally adopted are those formed of metallic lathing with plaster applied, sheets of compressed asbestos and cement, slag wool faced with metallic sheets, and slabs of compressed pumice and cement, with plaster applied. Most of the foregoing types can be constructed in double thickness, as with an air space between them, but in the case of a new building, the cost would be more than that of a concrete floor.

The report of the British Fire Prevention Committee in 1899 proved that by covering both sides and the ends of wooden floor joists with 1″ of slag wool, and by securing 1¾″ of the same material to the underside of joists with ⅞″ boarding below same, a fire of one hour's duration, with a maximum temperature of 1,800° F. resulted in little or no damage to the wooden joists or to the floor boards on the upper side of same.

Roofs.—For ordinary roofs no better material than reinforced concrete is known, though, having no loads except snow or hail to carry, the construction would naturally be of a lighter description than that of floors. The outer surface requires the application of weather resisting material to it, of which none better than natural asphalte exists. Such a roof, without the asphalte, will prevent the spread of fire from, or to, any roof that may be constructed above it.

A test made by the British Fire Prevention Committee in 1902 showed that a flat roof was constructed with deal joists (as a floor), and covered with 1¼″ boarding and three thicknesses of asphalted felt, finished with 2½″ of sand and gravel.

The underside was protected with wooden laths 1¼″ × ¼″, to which was applied 1″ of lime and sand plaster, with a small admixture of plaster of Paris. When dry, the structure was exposed to a fierce fire, with a maximum temperature of 1,500° F. for 1 hour.

In 40 minutes the plastering began to fall, and at the termination of the hour's exposure the fire had not passed through the roof, and it was sound enough to be walked upon.

Stairs.—Stone, especially of the calcareous description, must not be used for stairs, for if subjected to intense heat, though they may appear to be intact, they may collapse when stepped upon, or when water is applied. Concrete stairs, with a small T iron in each riser, are quite reliable. The landings should be of reinforced concrete, as to the floors, and at least 6″ thick. All doorways and passages opening upon staircases should be fitted with self-closing, fire-resisting doors, and the ceiling, at roof level, should be of concrete. These precautions prevent draught, and the spread of fire from floor to floor.

Walls and Partitions.—No safer material than brick in cement mortar exists for outside walls, though terra-cotta, backed with brick or concrete, is an excellent substitute.

For solid internal partitions, bricks, slabs of porous terra-cotta, or fireclay, concrete of suitable material and cement or gypsum plaster slabs are safe, and for hollow partitions the following are recommended:—Hollow terra-cotta slabs; expanded metallic lathing on both sides of steel studs, plastered with suitable material, and with air space between; sheets of compressed asbestos and cement secured to uninflammable impregnated wooden studs. In all the tests made, it appears that water applied to plaster when hot does as much, or more, damage than the fire itself.

The following list of tests, made by the British Fire Protection Committee, speak for themselves, and prove that the application of water had the least effect upon No. 1 (the hollow porous terra-cotta tile partition).

No. 1.—Partition of hollow porous terra-cotta tiles, 12″ × 12″ × 2⅛″, laid in cement 1 to 2, plastered on fireside with ⅜″ of asbestic, sand and grey lime The tiles were rendered

porous by mixing sawdust with the clay, which was consumed during the firing process.

Stood 2½ hours' exposure to maximum temperature of 2,000° F., and neither fire, water, nor smoke passed through it.

No. 2.—Partition of slabs of pumice, volcanic sand, and Portland cement 21″ × 11⅜″ × 2¾″ thick, plastered to make total thickness of 3⅛″.

Stood 2 hours' exposure to maximum temperature of 2,000° F., and neither fire, nor smoke passed through it.

No 3.—Partition of slabs of plaster of Paris and coke breeze 1 to 1; 24″ × 12″ × 2¼″, with one-sixteenth wires in joints, and plastered with ¼″ of plaster of Paris, and coke dust 1 to 1.

Stood 1½ hours' exposure to maximum temperature of 2,100° F., and fire did not penetrate it.

No. 4.—Partition of slabs of pumice, slag sand, hydraulic lime, tan and plaster of Paris, say, 4.0″ × 11″ × 2¾″, with five-sixteenth iron rods passing through same vertically at 12″ centres, and with ¾″ plaster on fire side.

Stood 1¼ hours' exposure to maximum temperature of 1,800° F.

No. 5.—Partition of slabs of plaster of Paris mixed with cocoa-nut fibre and cork dust and with reeds embedded horizontally. Slabs set in mortar composed of plaster of Paris, lime and sand mixed 2:1:2. Plaster 1¼″ (over two sides) thick. Slabs 4′ 10″ × 10″ × 2⅜ or finished 3⅝″.

Stood 1¼ hours' exposure to maximum temperature of 2,000° F.

No. 6.—Partition of bricks 13⅜″ × 7¾″ × 3¼″ composed of plaster of Paris, hydraulic lime, coke, sand, asbestos and sulphuric acid laid in mortar of hydraulic lime and sand, and plastered with fireclay on fire side, finished thickness 3½″.

Stood 1 hour of maximum temperature of 1,800° F.

No. 7.—A partition of terra-cotta and wired lathing plastered three coats both sides to a finished thickness of 2½″, the plaster being of lime, sand, and plaster of Paris.

Stood three-quarters hour exposure to maximum temperature of 2,000° F.

Hollow Partitions. — Partitions plastered both sides with steel or other inflammable lathing have proved to be practically useless when the studs to which the lathing is secured are of untreated timber. If the timber is rendered "non - flammable" by the process hereinafter referred to, the result would no doubt be more satisfactory; but, generally speaking, the cost of rendering hollow lathed and plastered partitions effective, even as fire resisters, entails so much labour and material that it is cheaper and better to adopt the solid partitions. The British Fire Prevention Committee, however, found as follows:—

A. A partition of corrugated helical steel lathing of ¾″ mesh, secured to 1″ × 1″ vertical iron studs at 24″ centres, with ½″ × ⅛″ iron bars fixed between them at 12″ centres, and running same way as the studs, plastered both sides with lime, sand, and hair, with 5 per cent. of Portland cement added, finished 2¾″ thick. Stood 1½ hours' exposure to a maximum temperature of 2,000° F.

B. A partition with 4″ × 2″ timber studs at 14½″ centres, covered both sides with wire netting, and over that ¾″ matched boarding; the whole space between studs being filled with silicate cotton (slag wool). Stood three-quarters hour exposure to maximum temperature of 1,800° F. The fire did not pass through the partition, though the inside boarding was consumed and the studs charred ¾″ deep. The outside boarding and the rest of the studs were intact.

C. A partition with 2″ × 1⅞″ deal studs at 18″ centres, covered both sides with ⅝″ grooved and tongued and beaded boarding treated by the Oxylene process as being non-flammable. Stood three-quarters hour exposure to a maximum temperature of 1,600 ° F., and the fire did not pass through, except at the tongued and beaded joints, which were the weak points.

Piers, Stanchions, and Columns.—The following are tests and results of same upon 6″ × 4½″ 20 lb. steel stanchions 13′ 0″ long, and loaded up to three tons, exposed for 2½ hours to a temperature from 1,800° F. to 2,100° F., encased as follows:—

No. 1.—With 4⅜″ terrawode bricks, 9″ × 4⅜″ × 3″, unplastered. Maximum temperature between encasement and stanchion, 310° F.

No. 2.—With 2½″ terrawode tiles, 9½″ × 12″ × 2½″, unplastered. Maximum temperature between encasement and stanchion, 1,100° F.

In both cases the stanchions were apparently unaffected.

The following are tests upon unprotected columns:—

No. 3.—A steel column composed of two 10 inch 15½ lb. steel channels, fixed 6½″ apart, web to web, with 12″ × ¼″ plates rivetted to flanges of both channels, giving an over-all sectional dimension of 12″ × 10″, with over-all length of, say, 14′ 0″ and load of 46 tons. Buckled at maximum temperature of 1,200° F.

No. 4.—A cast-iron column, hollow, round, 1″ metal, 8″ external diameter, over-all length, say, 13′ 0″, with load of 84 tons. Column red hot, and decidedly bent, at maximum temperature of 1,200° F.

Protected Steel Girders.—The following are tests and results of same upon 7″ × 2¼″ steel joists, say, 10′ 0″ between bearings, and not loaded. Joists covered with ⅜″, 24 gauge, No. 1 expanded metal, and 3⅜″ of a composition of water, plaster, hydraulic lime, coke sand, and asbestos, with an addition of sulphuric acid.

After exposure for one hour to a temperature from 500° F. to 1,600° F., followed by application of water at 25 lbs. pressure from a ½″ nozzle, the result showed that, though the encasement was cracked and sodden, it remained attached all around, and the girder was unaffected.

Non-Flammable Wood, etc. -- The treatment of wood, paper, or textiles to render same fire-resisting is of three kinds ; those which on heating leave an earthy deposit to protect the combustible material, those which fuse and form a glassy protective coating, and those which give off gases which stifle combustion. That under the first-named class is aluminium hydroxide; of the second and third, ammonium borate, and phosphate, giving off ammonia, and coating the material with boric or phosphoric acids. In the case of wood, the solution has to be forced in under pressure.

Tests made by the British Fire Protection Committee in 1899-90 proved that with identical partitions constructed of 1″ boards, both sides, those that were untreated communicated fire to an adjoining room in 18 minutes; whereas those constructed of non-flammable wood did not, after 45 minutes' exposure, when the test was suspended, and a maximum temperature of 1,545° F. had been registered in the pyrometer.

Textiles.—The tests upon textiles proved beyond doubt that even the most inflammable can be rendered slow-burning, and that asbestos blinds are valuable as protection to doors and windows.

Doors and Windows.—Doors and windows are amongst the most dangerous agencies for spreading fire in a building. Before going into the comparative values of materials, as proved by the tests of the British Fire Prevention Committee, I would remark that even if a door is absolutely fireproof, there is the danger of the fire spreading through the buckling and twisting of the door, or through the failure of its hangings and fastenings. Stone lintels should never be fixed above door openings on account of their liability to split, crack, or flake away when heat and water are simultaneously applied. In all cases woodwork should be avoided for linings or architraves to fire-resisting doors.

The results of tests upon several classes of doors have been as follows:—

Solid Wood Doors, 2″ thick all over, including the panels.

Oak.—Flame appeared outside in 30 minutes.

Teak.—Flame appeared outside in 24 minutes.

Deal.—Flame appeared outside in 20 minutes.

Pitch Pine.—Flame apppeared outside in 20 minutes.

Jarrah (1⅞″ thick, probably specially selected samples).—Flame appeared outside in 60 minutes.

Karri (1⅞″ thick, probably specially selected samples).—Flame appeared outside in 46 minutes.

Deal.—Ledged door 1″ boards, 3 ledges 6″ × 1″, 4 minutes.

Composite Doors.—2″ solid door, with core of built-up

strips of pine, covered both sides with ⅛″ asbestos boards, and each side finished with $3\frac{1}{16}$″ of oak veneer. Fire at a temperature of 1,500° F. did not pass through in 60 minutes.

1⅞″ solid door, core of two thicknesses ⅞″ pine, covered both sides with 26 B W G tinned steel sheets. Flame appeared outside in 12 minutes.

2⅝″ door, core three thicknesses of ⅞″ pine, covered as last. Flame appeared in 30 minutes.

2¼″ door, core two thicknesses of ⅞″ pine, covered both sides, with ⅛″ asbestos boards; and 26 B W G tinned steel sheeting. Flame appeared in 70 minutes.

Hollow Metallic Doors.—$1\frac{9}{16}$″ thick, with two $\frac{5}{16}$″ panels, all of 20 B W G tinned steel plates, with hollow between, fitted with two ⅛″ thickness of sheet asbestos with layer of impregnated felt between them as non-conductor.

Fire at a temperature of 1,570° F. did not pass through in 120 minutes.

Non-Flammable Wood Doors.—1⅞″ solid deal. Fire at a temperature of 1,680° F. did not penetrate in 60 minutes.

Solid Iron Door.—¼″ thick plate all over with 3″ × ¼″ stiles, and three rails of 3″ × ¼″ iron, screwed to the plate.

Through buckling, the fire passed through open spaces at the top and bottom in 19 minutes.

Concrete Doors.—2″ thick, with casing of 20 B W G steel plates, stiffened and reinforced by vertical steel bars, at 8″ centres, with ⅜″ cross bars to stiffen same.

The space between casing filled with concrete composed of pumice to pass ½″ ring, 48 parts; sand 16 parts; and Portland cement 15 parts.

Fire at a temperature of 1,800° F. did not pass through in 240 minutes.

Shutter doors.—Rolling shutters, constructed with interlocking strips or slats of steel, have proved effective checks to fire, especially when placed on both sides of a wall. Being thin, however, the one directly exposed soon gets red hot. If properly fitted, with properly protected gear boxes, they have withstood a 4 hours' exposure to a temperature of 1,800° F., and even then the outer shutter could be raised and lowered.

Windows require the most careful treatment, for if air can be excluded from a room, fire is naturally extinguished. If the glass of windows or skylights is broken by heat or water-jet, a fire raging inside a building would be intensified, and the flames would burst out and attack other windows across courts or areas. Wired glass has withstood severe tests, and can be considered a reliable material for the passage of light and resistance to fire if properly mounted, but the danger still remains in the frames or sashes that hold the glazing. Electro-glazing, wherein bars of metal and small squares of specially-prepared glass are electrically fused into one homogenous slab, is the best known material,

and is superior to wired glass, but very expensive. Wired glass must be of the best material as the cheaper makes may crack when exposed even to extreme sun. The cracks then get dirt-laden, and admit damp to the wiring, which corrodes and causes failure when an extreme test is applied. Electro-glazing has the advantage of being entirely transparent, and though it may crack when exposed to extreme heat, the pieces will be retained by the bars, and not fall out. The safest types of sashes are those made of hollow metal, steel or hardwood, according to circumstances, and the frames should be of the same material, carefully stopped around their joints with the walls, with incombustible and permanent material that will resist displacement when exposed to fire or water. As a rule, it has been found, when an actual conflagration occurs, that water applied to hot glass causes a more dangerous disintegration of the material than the fire itself, and that hard wood is less affected than metal framing.

The results of tests upon several classes of windows have been as follows:—

Horizontal Sashes to Skylights.—¼″ wired rolled glass to concrete reveals sight sizes 2′ 0″ × 2′ 0″ withstood a maximum temperature of 1,520° F. for 60 minutes.

The same glass secured to teak frame of sight size 4′ 7½″ × 2′ 6″ withstood a maximum temperature of 1,475° F. for 30 minutes, but bulged 2″ in the centre.

Vertical Sashes.—32 oz. sheet glass 3′ 0″ × 4′ 0″ to teak frame. Maximum temperature 1,050° F. failed in 6 minutes.

Lead glazing in 4″ squares. Maximum temperature 1,500° F., collapsed in 7 minutes.

¼″ plate glass 3′ 0″ × 4′ 0″ to teak frame. Maximum temperature 1,550° F., failed in 12 minutes.

¼″ wired rough-cast glass 2′ 3″ × 2′ 3″ to teak, iron and brick reveals maximum temperature 1,500° F., withstood for 45 minutes.

¼″ wired rolled plate glass 4′ 0″ × 2′ 10″ to teak frames buckled, and let fire pass at maximum temperature of 1,600° F. in 30 minutes, and at 1,715° F. the glass fused in 7 minutes.

Electro-glazed sheets 4′ × 3′ with 4″ × 4″ prisms, teak frames, at maximum temperature 900° F., bulged 2″ in 12 minutes, and at maximum temperature 1,315° F., the glazing sagged and left frames in 21 minutes.

7 out of 324 prisms were fractured, and the teak frame charred ½″, with maximum temperature of 1,520° F. in 30 minutes.

Electro-glazed sheets 2′ 0″ × 2′ 0″ to steel frames at maximum temperature 1,630° F., glass sintered, bulged ⅛″, and solder melted, but fire did not pass in 90 minutes.

The above tests proved that the larger sheets of glass are less effective than the smaller. It is to be hoped that tests will

be made of lights composed of mica plates secured to asbestos framing, and of glass bricks set in gypsum.

Conclusion.—In conclusion, I would express the hope that at our next congress we may be favoured with a paper dealing with fire-resisting "construction" in buildings, and upon the application of the materials I have dealt with, and others to their best uses. The two subjects are naturally allied, as the one depends upon the other.

The object of fire-resisting construction is the employment of such materials and systems of construction as will retard an outbreak of fire on the one hand, and its progress or development on the other, thus preventing a dangerous conflagration in a building, and giving sufficient time for the escape of the occupants, the salvage of the contents, and the arrival of the fire brigade to cause its extinction.

Everything seems to depend upon the planning of a building so that all chances of a fire spreading are reduced to a minimum, and this can only be secured by dividing it into a maximum number of safe units both horizontally and vertically.

This is absolutely the work of the architect, and one that no engineer of repute should undertake unless he has also been trained as an architect or co-operated with one who has had the necessary special experience in that class of building.

Poisoned Bait for Biting Flies.—During experiments made by Mr. C. W. Mally, Government Entomologist, at the Entomological Experiment Station, Rosebank, Cape Province, the biting house fly, *Stomoxys calcitrans*, was destroyed by means of a liquid poisoned bait, containing 1 per cent. of sodium arsenite and 10 per cent. of sugar. This has suggested the possibility of destroying other biting flies, *e.g.*, tsetse flies and certain Tabanidæ in the same way. The Tabanid *Hæmatopota ocellata* Wied is very abundant around the vleis in the Cape Flats this season, and an effort is being made to determine whether this fly can be attracted to poisoned bait in the field.

ANHYDROUS LIQUID HYDROCYANIC ACID FOR FUMIGATION PURPOSES.

By Charles William Mally, M.Sc., F.L.S.

For the destruction of insect pests on fruit trees by means of hydrocyanic acid gas the usual practice is to generate the gas by the action of dilute sulphuric acid on potassium or sodium cyanide, either (*a*) dry or (*b*) in solution. Either method leaves much to be desired, for it not only takes time and care in preparing the chemicals, but there is also the danger of burning the tents by acid coming in direct contact with them through handling them; or the absorption of fumes or vapours driven off during the generation of the gas may result in the familiar "rotting" of the canvas. The above factors are of special importance in connection with vineyard fumigation for the destruction of the mealy bug, *Pseudococcus capensis* Brain, because the vines, whether trellised or "bush," must be covered with long, narrow sheets of gas-proof canvas, almost the whole of which is in close proximity to the freshly-generated gas by whatever means it is produced. The space enclosed is very small, and hence only a small amount of gas is required. On account of the shape of the tent, the gas should be liberated at several points to secure a quick and uniform distribution. This means a number of small generators or points of introduction from an external generator. In military work the trouble with acid and cyanide and generators increases the amount of strict supervision necessary, and the time required to do the work. On going into the matter of possible ways of improving on present methods, I decided to try to make use of the fact that the gas readily condenses on being subjected to a low temperature, and produces the anhydrous liquid hydrocyanic acid. The matter was discussed with the Government Analyst, Dr. C. F. Juritz, and later on, with the assistance of Mr. W. W. Brighton-Manning, in arranging the details of a small experimental apparatus, a small quantity of the liquid acid was produced at the Entomological Experiment Station, Rosebank, Cape Province.

The liquid acid proved to be much easier to work with than was anticipated. On testing it with different insects, I came to the conclusion that the gas arising from the *liquid* diffuses more quickly, and is more violent in its action than that from an ordinary *generator*. This is probably due to the absence of moisture or other impurities, which may, in the case of *generator* gas, have a retarding effect. If this holds in practical work it is an important item, for it involves a smaller amount of gas or else a shorter exposure.

Portions of ordinary silk ribbon, muslin, and boat-sail drilling saturated with acid showed no ill-effects after a fortnight. This also is of considerable practical importance, for it indicates that the "rotting" of fumigation tents under present methods is due to impurities from the ordinary generator. Whether there is a corresponding reduction in the injury to plants has not been determined.

The dangerous nature of the acid must not be overlooked, although, on the whole, with equal care in giving instructions as to its use, I consider that it is no more dangerous than bisulphide of carbon.

Under normal trade conditions, it may be possible for manufacturing chemists to produce the anhydrous liquid acid economically, possibly from low-grade materials that are not suitable for fumigation under present methods, and ship it as a commercial article in place of the cyanide and acid. In such case, it will simplify practical work, because the acid which vaporises very quickly on exposure to the air, can be injected through suitable openings in the tent or other enclosed space, and thus do away with disagreeable and cumbersome generators and the accompanying byproducts. The practical results should be more reliable than by present methods.

A larger apparatus is being arranged with a view to producing a sufficient quantity for field tests.

ALCOHOLOMETRIC TABLES.—In connection with the article "Alcoholometry" in Sir Edward Thorpe's Dictionary of Applied Chemistry, a series of tables is given for ascertaining, from the specific gravity of mixtures of alcohol and water, the proportions of alcohol and of proof spirit in such mixtures. These tables have recently been extended, and are now published in book form.* All who have to carry out frequent and accurate determinations of alcohol, in liquids presumed to contain it, will welcome the appearance of this handy little book. The names of Blagden and Gilpin, of Tralles, Gay-Lussac and Sikes were long familiar in connection with earlier tables, but those of Sir Thomas Stevenson, compiled 35 years ago, were never surpassed in accuracy or completeness. Sir Edward Thorpe has carefully sifted all previous records, and the present volume is the final result. For laboratory use its columns of widely spaced figures in heavy Clarendon type offer the advantage of rapid and easy reading for all who, in the distillation of industrial or other spirits, desire special accuracy. The introduction preceding the tables has an interesting account of the history of alcoholometry. Rapidity of reading would be further advanced in future editions by the provision of a marginal (thumb-hole) index to the tables.

* "Alcoholometric tables." By Sir Edward Thorpe, C.B., LL.D., F.R.S., pp. xiv, 91. London: Longmans, Green & Co. 1915. 3s. 6d. net.

ECONOMICS OF THE WAR.

By E. C. Reynolds.

The economical effects of a European war have been the subject of discussion for many years. The interdependence of the financial and commercial relations of the leading nations has increased so rapidly within the past half-century that the problem has become one of extreme complexity, and the old days, when a nation was more or less self-contained, have long since passed away.

Unfortunately, the commercial rivalry and the land hunger of those nations having steadily increasing populations have been backed by the establishment of immense armaments, and the menace of these armaments has been particularly grave for the last five or six years. It was hoped that the great economical sacrifices that war involved, would prevent a general conflagration, and a school of thought, of which Mr. Norman Angell is the exponent, has shewn, and in my opinion conclusively shewn, that the economical advantages to be gained by war are a myth. Prior to the war, the opinion was freely expressed by prominent commercial and financial authorities that, for economic reasons, a European war could not last many months. The food supply, and also the supply of the raw material necessary in connection with the highly complex business of modern warfare, such as petrol, nickel, copper, and many other items of this nature, would be exhausted in the very early stages, and importations would be prohibitive. Further, all importations would have to be paid for in gold or by the realisation of foreign investments, and such a drain could not be met for any extended period. A very severe and disastrous financial crisis in London and the foreign capitals was anticipated,—the extent of which could not be foreseen, but at which the financial world shuddered. These forecasts are of no particular value now, but are interesting as indicating how exceedingly difficult it is to follow out the ramifications of modern finance and commerce, and the effects of a general disturbance such as we are now passing through. I am, of course, dealing with the material side of the question, leaving out the pain, anguish, and sorrow caused by war under the most humane conditions.

Before war actually broke out, the financial barometer plainly shewed that storms were ahead. Prior to the declaration of war by Austria and Germany against Servia, Russia, and France, a depression had come over the various bourses of the world which, to those not behind the scenes, could not be explained. We now know that Germany, particularly, was selling a large portion of her foreign securities through the agencies of the German Banks, and, further, the German and Austrian Banks, having foreign agencies—particularly in

London—were calling in their loans on the Stock Exchange. This had a similar effect as though they were selling securities. Germany adopted this course in order to increase the rapidity at which she had been accumulating gold in recent years. She had been importing very heavily, and consequently the selling of investments was the only means of adjusting her exchange; otherwise the payment of her imports would have necessitated parting with gold.

Germany's action naturally had a depressing effect on the market, and, when war actually did break out in August, it was necessary for each belligerent and neutral power to carefully examine its national balance-sheet.

I specially mention Germany, as that nation, from the point of view of armaments and the temper of its military caste, was the most important factor in the situation.

The assets of a nation—in times of peace, developing on ordinary lines and becoming wealthier each year—are valued in accordance with the means they give of steady growth in wealth and importance. In face of war, however, when a country has to defend itself against the aggression of its neighbours, the value of its assets alters considerably. This will be illustrated if we view the position of some of the countries before the war broke out, and later review the position after some months of war.

Germany.

At the outbreak of war Germany had a population of 66,000,000.

Her national debt, including state debts as well as the imperial debts, was £1,030,000,000.

Her imports were £535,000,000, and her exports £500,000,000, the balance being settled by interest on investments and services rendered.

The holding of gold by the Reichsbank had been steadily increasing of late years, and had reached £60,000,000. In foodstuffs she was very nearly self-supporting. Taxation was heavy, but there was no direct taxation in the form of income-tax.

She was spending at the rate of £70,000,000 a year on her army and navy. Estimates of expenditure, 1914, were £175,000,000. Credit was good.

Austria-Hungary.

Austria-Hungary's population was 57,000,000. Her national debt was £794,000,000.

Her imports were £140,000,000, and her exports £114,000,000. The holding of gold was £51,000,000.

In the necessities of life she was more or less self-supporting.

Her annual budget had shewn repeated deficits, her finan-

cial credit was none too strong, and she could enter the market only on a 5 per cent. basis.

France.

France had a population of 40,000,000. Her national debt was £1,015,000,000.

Her imports were £330,000,000, and her exports £270,000,000.

Exchanges were slightly against France, but the majority of the difference was settled by interest on foreign investments and services rendered.

The gold of the Bank of France was £140,000,000.

Food supplies were not of importance in view of her large coast-line.

Taxation was not severe, and her credit was first-rate.

Revenue and expenditure balanced at £180,000,000.

Russia.

Russia had a population of 170,000,000. Her national debt was £945,000,000.

Her imports were £125,000,000, and her exports £170,000,000.

Owing to the excess of her exports over her imports, Russia had been able to accumulate a large holding of gold, which at the outbreak of war amounted to £174,000,000. Russia is self-supporting with regard to foodstuffs. Her budget shewed an annual expenditure of £300,000,000, balanced by the revenue.

Her credit is good.

The United Kingdom.

The population of the United Kingdom was 46,000,000.

Her national debt was £720,000,000.

Her imports were £750,000,000, and her exports £500,000,000.

The very large balance of imports over exports represents the return for capital invested abroad, and also for large services rendered by shipping.

The gold held by the Bank of England at the outbreak of war was £36,000,000.

The free importation of food supplies is necessary for the existence of the population, and safety in this respect has been assured by our financial sacrifices to insure our naval supremacy.

The annual budget had shewn a revenue of £200,000,000, and in 1913-14 a surplus of £750,000 was realised.

British credit was the best in the world on a 3 per cent. basis.

The British Dominions.

The population of the British Dominions is 388,000,000, including all races. Excluding India, 65,000,000.

In nearly all cases the Colonies are developing, and therefore absorbing large amounts of capital, for which they come to the Mother Country. Colonial credit was good.

The gold from South Africa, the grain from Canada, wool and meat from Australasia, cotton, grain, etc., from Egypt and India were all-important factors in supplying the requirements of the thickly populated European countries.

To summarise, the above nations were all in a flourishing condition. They had each a reasonable army and a fleet to protect them against any foreseen aggression. Their population and wealth were increasing on normal lines.

Immediately war broke out one item of their resources at once assumed immense importance, and that was the provision they had made for war. To keep a large standing army, to provide food and arms for the possible mobilisation of all available forces, to provide for a large and important navy, and for the recent developments in air-ships and aeroplanes, means a great tax on the resources of a country. All countries have appreciated the necessity of making sacrifices in this direction, and in many cases, with the idea that such sacrifices were unnecessary.

The brains that are devoted to the invention of engines of destruction could be better utilised in evolving inventions of direct benefit to humanity. The years given to military service by conscripts in those countries where service is compulsory could be better employed in fitting the individual for his ultimate sphere in life. It is only natural, then, that a nation should hesitate at the sacrifice necessary for its security. In practice, it is often extremely difficult to persuade an individual to insure against contingencies and nations have shewn the same hesitancy.

The first effect of the declaration of war was to paralyse the foreign exchange markets. London, being the clearing-house of the world for the exchange market, suddenly found that some of the spokes of the wheel were broken, and until, speaking figuratively, the wheel could be adjusted, it caused great disturbance, to such an extent that a moratorium had to be proclaimed at most of the large centres of the world, and to avoid a panic at the Stock Exchanges all the bourses were closed. The Bank of England rate jumped suddenly on the 29th July from 3 per cent., and rose rapidly in two or three days to 10 per cent.

On August 8th it was reduced to 5 per cent., a more or less normal rate. Fortunately, so far as London was concerned, the August Monday Bank Holiday intervened, which gave the Government and the financial heads a day or two to consider the situation, and they very wisely extended the Bank Holiday from the Monday until the following Friday. Meanwhile, many arrangements were made, and by the time the Banks re-opened on the Friday the situation had been explained to the

public, and a panic was averted. At first, business was naturally very restricted, but in so far as the financial centre, namely, London, was concerned, the Government and the business heads worked in perfect unity for the common good, and the arrangements made to meet the great crisis seem to have been almost beyond criticism. It was arranged by the Government with the Bank of England to discount, or advance against, the bills in the hands of the financial institutions, and the knowledge that these bills could be renewed at maturity gave breathing time to the commercial world. The result, so far, has been that few failures have been recorded in England or her Colonies consequent upon the war.

The London Stock Exchange was closed from the end of July, 1914, until the commencement of January this year, and when it was reopened minimum prices were arranged for certain stocks, so that dealings could not take place at below that minimum, the idea being to avoid undue selling and the resultant great losses.

In the first instance America felt the war very keenly because of the derangement of her imports and exports, and, to begin with, their indirect losses were very great, but after the first few months the orders from the belligerents for munitions, foodstuffs, etc., were so large that that country has, no doubt, prospered rather than otherwise. The exchange position was relieved by New York bankers depositing £20,000,000 at Ottawa, to be held there on behalf of the Bank of England. Further, an arrangement has been come to under which the movement of large quantities of gold to settle exchanges will be obviated. Not all countries, however, had these compensations.

Brazil, for example, was very adversely affected, in the first instance owing to the fact that it was just arranging a big loan with the European countries in order to settle some outstanding matters when the war broke out and stopped negotiations. The chief products of Brazil are coffee and rubber, and for the former article Germany and Austria are probably its largest customers, but on account of the war these shipments have been stopped, and the result has been great depression, the country defaulting in payment of interest on public debt.

The Argentine and other South American countries find the greatest difficulty in obtaining freight for their surplus produce, which is the main source of their wealth, and it has resulted in the Province of Buenos Aires defaulting in paying the interest on their public loans, whilst some of the railways have also failed to provide the interest on their debentures, etc.

We, in South Africa, have much to be thankful for. Immediately it was known that war had broken out in Europe, the Government called a conference of bankers, mining houses, and merchants, and the machinery to arrange many matters was formed in case of necessity. The most vital matter, namely, the financing of the gold industry and the shipment of that

product—which involves approximately 36 millions sterling per annum—was arranged by the Bank of England, through the British Government with the Union Government, so that the Banks could advance the gold-mining companies here against the delivery of their gold, and, in turn, the banks obtained from the Bank of England in London the equivalent. Directly this matter was arranged, South Africa could breathe freely, because, had it been impossible to ship, and had the Bank of England not devised this safeguard, the closing down of the gold mines and the cessation of what, after all, is the chief industry of this country would have followed. The Government also arranged with the banks for the financing of the wool industry, and many other smaller but important matters were satisfactorily provided for in case of contingency arising. Unfortunately, the diamond mines had to be closed down because their product, being an article of luxury, the demand suddenly ceased, which entails a temporary loss to South Africa of approximately 12 millions a year. The ostrich-feather market in London was supended, but has since been partially reopened. As against this temporary loss of turnover, the Government's expenditure connected with the war in German South-West Africa and the Rebellion has to be taken into consideration. This, however, is of only artificial assistance to the country, as taxation must be imposed to meet the costs of the abnormal outlay, the cessation of which, moreover, must naturally be felt by the commercial community in the Union.

The large fabric of credit, which supports the commercial world, has stood the strain remarkably well, and the disastrous forebodings of the pre-war prophets have not been realised.

When the first blow of the declaration of war has passed, and the initial financial crisis has been tided over, the economic effects are not immediately felt. The Government regulation of food-stuffs may be necessary; the abandonment of many luxuries is forced upon the nation; and there are many cases where manufactures have to be given up owing to the difficulty in obtaining raw material. On the other side, however, there is the immense demand for men for the army, the activity in the military and naval factories, and also in those centres engaged in supplying the needs of an army. It is very probable that in the belligerent countries trade is not feeling the effects of the war yet to any great extent, because the huge expenditure necessary to keep the large armies in the field and the manufacture of munitions keeps labour more than fully employed, and, even if one trade is temporarily closed, the relative labour can be transferred to the making of munitions and so forth. In the meantime, the various Government expenditures avoid any very great distress being felt, and unless some of the belligerents find it difficult to obtain food-stuffs on account of maritime blockade, it is quite probable that trade in all the countries at war is, on paper, quite good in the meantime.

Redistribution of employment soon takes place, and the Government, by running up large debts, hides from the public, for the time being, the sacrifices being made.

We can now examine the position of the principal countries after eight or nine months of war:—

GERMANY.

By the establishment of War Credit Banks and the issue of notes by the Reichsbank and these institutions, with denominations as low as 1s., gold has been diverted from the pockets of the public to the National Treasury, whose holding of gold has increased from £60,000,000 to £120,000,000. It is estimated that the total amount of gold obtainable in Germany is 150 millions.

The notes are legal tender and inconvertible. The total amount of the issue is not available, but they must have now reached enormous figures, and when the war is over the country will be faced with a very grave problem when required to redeem these promises to pay in gold.

Germany has raised loans on a 5 per cent. basis which, as far as can be ascertained, total about 570 millions.

At the outbreak of war, taxation had reached a limit as regards indirect taxation, and the country is now faced with the problem of having to levy some direct tax in the nature of income tax. Owing to the falling off in foreign trade, the return from indirect taxation has decreased at a tremendous rate, so that the problem to be faced is a serious one.

Very nearly 50 per cent. of their foreign trade was with the Allies, and the trade they have been able to conduct with neutral countries cannot possibly have replaced this shrinkage.

The foreign exchange rates since the war have been against Germany, and increasingly so. They have already had to forward five millions of gold to Denmark and Scandinavia. The falling off in their exchange rates is partly accounted for by the depreciation in their currency, and as time goes on they will no doubt, in order to adjust matters, have to export large amounts in gold.

They are supposed to have an army in the field approximating five millions, and their industries generally have been mobilised on a war basis. It is presumed that their supplies of war materials in many cases are becoming exhausted, but information on this point is exceedingly difficult to obtain. With regard to food, the matter was exhaustively gone into by a committee of German scientists at the time England declared her blockade of food-stuffs. The results of their investigations were published in the German Press. It was found that a certain quantity of food-stuffs was required to keep their population in normal health and strength; this was about, roughly, two-thirds of their consumption before the war. Their supplies at the time fell slightly short of this requirement, but by saving

and by increased production, it was shown that their resources could supply well in excess of their minimum requirements.

Austria-Hungary.

In Austria-Hungary War Credit Banks have also been established, and a note issue forced on the public on an inconvertible basis. The banks published no statements, so that it is impossible to say whether the gold reserves of their banks have been increased. At the outbreak of war they held 50 millions. It is believed that some of the gold has been transferred to Germany, but an estimate gives the present figure as 80 millions.

They have raised internal loans of £130,000,000 for Austria at 5½ per cent., and £60,000,000 for Hungary at 6 per cent. A further loan approximating £200,000,000 has been issued, the result of which is not known. The country had a form of direct taxation, but what has happened in this direction since the war is not known. The position of their credit, however, in their budget must be an extremely unfavourable one, and they are estimated to show a deficit of 33 millions for the current year. From a quarter to a third of their foreign trade was done with the Allies. Owing to the Adriatic being closed, their over-sea trade generally has suffered severely. They are forced to rely on their internal resources. They are estimated to have in the field an army of 3,500,000 men, and, as in Germany, their industries have been mobilised to meet the new situation. Their supplies of material for the conduct of the war must be limited. With regard to food, however, they appear to have no serious difficulties to meet.

France.

The Bank of France have increased their note-issue from 240 millions to 460 millions, and it is inconvertible.

The gold held is 170 millions, as compared with 140 millions.

France has raised loans mainly by the issue of Bonds of National Defence, carrying interest at the rate of 5¼ per cent., to the extent of 400 millions. In addition to this, she has recently placed 10 millions of one-year bills in New York, and I understand that Germany also placed a small amount.

In order to adjust exchange, the American bankers placed, at the time of the war, 20 millions at their disposal, as they had done in the case of Great Britain. Since then six millions of this have been withdrawn to adjust exchanges.

France's shipping has been practically uninterfered with. Information is not available, but there is no doubt that they have bought very largely in America, with the result that a big balance will have to be met by the sale of foreign securities or export of gold. France is estimated to have in the field an army of four million men, and the whole of the male population, between the ages of 20 and 48, has been called to the colours. As every man in France is a soldier, it has been easy for that country to

effect a thorough mobilisation of its industries, and there has been, so far, no hint of any hitch in organisation.

France has the sea open to her, and her supplies of war material and food are only limited by the freight difficulties which now exist.

Russia.

Russia has increased her note circulation from a normal amount of 50 millions to 222 millions. Her holding of gold is 171 millions, as compared with 160 millions; she has, however, exported eight millions of gold to England.

Russia has raised internal loans of £200,000,000 on a 5 per cent. basis, and in addition to this the British Government lent her 12 millions to pay the coupons on her debts maturing in December last.

The Russian budget has been seriously affected by the prohibition of the sale of vodka, which brought in a return of 40 millions. It is, however, a country of enormous resources and a population of 170 millions. It is anticipated that they will have no serious difficulty in arranging their finances, although it is probable they may require further help from their Allies until their resources are better organised.

Her foreign trade, particularly her grain export, has been seriously affected owing to the closing of the Dardanelles and Baltic. It is thought that operations now in progress in Gallipoli will eventually release the grain ships and adjust this position.

Russia is estimated to have actually in the field an army of five million men. The provision of equipment and munitions has, however, been a very serious problem. Reliable information on this subject is not obtainable, but there are indications that the Russian retreat in Galicia has been mainly owing to the lack of munitions. This difficulty will no doubt be overcome in time.

Great Britain.

Great Britain has partly met the position by the issue of Treasury Notes, but to nothing like the extent of her Continental neighbours. The total did not exceed £50,000,000, and although the gold holding of the Bank of England has increased to 56 millions, this amount is quite unimportant when the country's commitments are examined.

During the first eight months of war the revenue was £226,700,000, the expenditure was £560,500,000. The deficit of £330,800,000 was met by the loan of 350 millions at 4 per cent., issued in November last year.

Mr. Lloyd George, in his Budget speech, disclosed the following estimates for the year April 1st, 1915, to April 1st, 1916, on the assumption that during the whole of that period we should be engaged in war:—

Revenue	£270,000,000
Expenditure	£1,132,600,000
Leaving a deficit of	£862,600,000

In order to meet this deficit, the Government have to raise further internal loans, and the public are now asked to subscribe to a 4½ per cent. loan for practically an unlimited amount. The result of this loan, which is not yet closed, is of course unknown, but it is confidently hoped that the appeal to the patriotic spirit of the nation will make the scheme a success. The estimated savings of the country in peace time are annually 300 to 400 millions, and Mr. Lloyd George states that if the nation will realize the position and save 20 per cent. of its income, the deficit can be met. The addition of 1,000 millions to our national debt, bringing it to 1,720 millions, will only represent a mortgage of 9 per cent. of the actual value of the national property; after the Napoleonic Wars, a hundred years ago, the national debt was 33 per cent. of the estimated value of the national property. Of the expenditure this year, 200 millions represent advances to the Allies and Colonies,—the remaining 932 millions is for our own expenditure.

A large proportion of this abnormal expenditure will be made in the Colonies, America, and neutral States, with the result that the exchanges against England will be very seriously affected. It is estimated that during the year the imports will exceed the exports by 400 millions. This balance will require to be settled either by the sale of foreign securities or by the export of gold. We have already paid New York 6 millions from the reserve established at Ottawa, but our holding of gold in Great Britain will not stand any serious withdrawals. It would appear, therefore, that the realization of securities will have to be faced. In order to avoid the complication that has arisen, the British Government have foreseen the necessity of taking in hand at once the mobilization of our industries on a war basis, so that we can avoid purchasing abroad and supply our own wants. The problem had already been dealt with by Germany and France, but we are only now realizing the importance of the step. The present conditions open an extremely promising field for the Colonies, and especially in South Africa, to establish an export trade in grain, meat, and wool on a firm basis, which I trust will be taken full advantage of. It is estimated that 2 million men are under arms, which is extremely small in comparison with the population of the British Empire. We have control of the seas, and need not fear for our supplies of munitions and food. The great difficulty our statesmen have had to face, has been to bring the British public to appreciate the necessity of submitting to Government regulation until the present crisis is over.

Italy.

I must also mention that Italy, after having kept her army mobilized practically from the commencement of the war, has now actively undertaken operations against Austria.

Italy has a population of 35,000,000 people, and her army, on a war footing, is estimated at 2,000,000.

At the outbreak of war, the Italian debt was £522,000,000.

All Italian securities, since the beginning of hostilities, have shown a very heavy drop, and her credit is only fair. To meet war expenditure, Italy is now raising an internal loan.

Italy exports £100,000,000 per annum, and imports £145,000,000. Thus another important nation is now diverting her energies from productive channels to unproductive war expenditure.

Turkey.

Turkey's position, either economically or financially, has never been good—the second being the result of the first. The Ottoman Bank, just prior to the outbreak of war, refused to pay out coupons except in Constantinople. Turkey's finances have gradually drifted to the control of the German banks, and the present position is obscure.

It is to be hoped that, in the case of Turkey, the strain of war may tend to the development of sounder principles in Government.

I have briefly reviewed the position with regard to the principal belligerent nations, and it is not possible, in a paper of this short extent, to make much reference to the smaller communities affected by the war. I may mention that our ally, Japan, spent just over £5,300,000, which was paid out of surplus revenue.

It will thus be seen that the principal steps taken by the nations involved have been:—

1.—To encourage the issue of notes of small denominations in order to divert gold to the public Treasuries, so that an ample reserve is maintained to settle the large balance of imports over exports necessitated by the consumption of war material.

2.—Raising of enormous internal loans to provide for the payment of troops and provision of munitions.

3.—The mobilization of all industries with a view to insuring that, as far as possible, the requirements of the Government shall be met within the State. The importance of this step has only recently been appreciated in England.

4.—Public appeals to the country to reduce the consumption of luxuries and loyally support the Government in the prosecution of the war by avoiding all internal trade disputes.

As I have previously stated, the cost of the war, including the loss of life, the decrease in production, and the destruction of property, is not immediately felt. The bill will have to be met eventually, and it is necessary now to review the cost.

To try and ascertain what the economic result of this gigantic war means, we have to realize that practically every-

thing spent on war material is directly unproductive outlay, and consequently the bulk of the capital spent is destroyed for all time. Naturally, if a country spends a certain sum on war and through spoils of victory obtains valuable territory, or other similar consideration, then it is a question of calculation as to whether the considerations make the expenditure productive—the gains are often found by examination to be illusory. Speaking generally, all war expenditure is a loss of capital to the world. It is estimated that the cost to the Government per day of the war in England is £2,700,000—the other chief belligerents must be spending more,—the total cost can be estimated in the neighbourhood of £12,000,000 per diem.

An interesting article appears in *The Economist*, of 9th January last, giving an estimate of the cost of the first six months of the war for the five principal nations involved. This showed the following totals:—

Armies involved, 18 million men.
Cost to the Governments involved, 1,660 millions.
The estimated value of lost production, 2,240 millions.
The total population of the countries was 374 millions.
The total foreign trade was 3,523 millions.

The national income of the individual nations was estimated:—

Germany	2,100	millions.
Austria-Hungary	900	,,
France	1,250	,,
United Kingdom	2,250	,,

For Russia the figures are not known.

The national wealth of the nations is estimated:—

Germany	16,000	millions.
Austria-Hungary	9,000	,,
France	13,000	,,
United Kingdom	18,000	,,

Figures for Russia are not known.

The proportion of direct cost to the national income for both sides is estimated at 43 per cent. The proportion of total costs to the national income is estimated at 96 per cent.

The above takes into no account the loss of capital represented by the loss of life or the destruction of property.

The capitalized value of the loss of life in the war over a period of one year has been estimated as follows:—

Great Britain	300	millions.
Germany	79	,,
Belgium	40	,,
France	348	,,
Austria-Hungary	240	,,

For Russia the figures are not given.

The value of property destroyed is given as:—

Belgium	250 millions.
France	160 ,,
Austria-Hungary	100 ,,

The low value of the loss of life to Germany appears to be based on the fact that the German population was increasing very rapidly—by 1,000,000 per annum—with no outlet in German territory. It is estimated that 600,000 Germans emigrated annually to other countries.

Estimates on a really reliable basis are impossible, and the end of the war is, unfortunately, not yet in sight, and it is quite impossible to forecast the other losses involved. The extraordinary progress that the world has made in the last century in science, literature, and humanity, has received a rude shock. The mechanical and scientific inventions have been turned to destroy the very progress which gave rise to their existence The effects can be considered briefly under various heads:—

Population.

A human being, even though he may have no material effects personally, is worth a certain amount of capital to the nation, and the nett capital value of a soldier killed, who is a man in the prime of life and at the highest point of his productive powers, has been estimated at £800. The following factors enter into the calculations:—

1.—Taxes paid by each man killed.
2.—Cost of supporting those originally supported by him.
3.—His buying power.
4.—Profit due on work done by him.
5.—His savings.

On this basis, if, during the first year of war, one million men are killed, there has been a loss of capital to the amount of 800 millions. Probably, however, the loss may be very much higher. This loss of manhood cannot but have far-reaching results to the nations involved. One result of the war will probably be the increased number of women employed in commercial life. Scarcity of labour has already led to the enlistment of female service in many branches of trade and business where duties were hitherto performed by men, and that the innovation will, to some extent, be continued appears to be very probable. Whether it is wise to encourage this tendency, because of the ousting of male labour and the consequent reduction in wages is to be doubted, but for the present the times must be served.

Capital.

Directly the war ceases, some of the belligerents will for a time experience unprecedented distress; many unemployed, industries temporarily closed down or trade so dislocated that

employment cannot be found for the labourers. Taxation in some countries will, of necessity, have to be so abnormal as to become almost impossible to meet, and even those countries where towns and factories have not been destroyed will be in the position of a firm re-starting business with very largely diminished capital. A country, after all, like an individual or a firm, cannot trade without adequate capital. One serious effect of the war, as concerns the wealth of individuals, is likely to be the serious loss in the value of securities. I am afraid that some countries must of necessity default after the war; that is, they will be unable to bear the burden of paying interest on the huge loans they are now contracting. Some smaller States must also keenly feel the pinch, because of the diminished spending powers of larger countries who were formerly their best customers, and to whose markets they chiefly looked for the sale of their products. All this must react severely upon the value of many investment stocks, and the individual investor will suffer in loss of capital and revenue.

Just after peace, it is true, there must inevitably be a strong demand for capital wherewith to make good the ravages of war. Reinstatement of property on a large scale will be undertaken and interest in consequence may be high, but when this artificial activity has subsided I fear we shall see an era of considerable depression.

The great loss of capital brought about by the war must, on the cessation of abnormal expenditure, reflect itself in diminished volume of trade and lesser spending power of the people. Not all countries will, of course, suffer alike, for to some—not directly penalised by the war—will have come opportunities for capturing and retaining trade of which the present conflagration has deprived others.

It is difficult to express an opinion as to the probable cost of living after the war. Reverting to our argument that practically all expenditure on war means the total destruction of a corresponding amount of capital, this line of reasoning should lead to the conclusion that living costs will be greater after the upheaval.

Taxation, in the belligerent countries, must be greatly increased, and drastic economies will have to be practised, not only by Governments, but by individuals.

There would appear to be no question that what is termed the leisured class, which is dependent on revenue from investments, will find its income seriously curtailed. This depletion may not only be caused by taxation, but also by reason of the possible default of certain Governments to pay interest on their loans. The capital of this section of the community will thus shrink as a consequence of the fall in the value of some of the securities in which it is invested. On the other hand, those who are fortunate enough to have cash capital in hand may be able to employ it profitably. As concerns the working

classes, if I am correct in assuming that the cost of the necessaries of life is to be greater then without higher wages, these will also be worse off. I, however, am inclined to the view that wages will have a tendency to increase more or less in proportion to the rise in the cost of living, and the effects of the war should be felt to the greater extent by the leisured class.

The demand for luxuries has, during the last fifty years, increased enormously, and retrenchment in this regard will, I am convinced, be one of the inevitable consequences of the war. Capital, hitherto invested in the manufacture of articles of luxury may, it is true, be diverted to the production of necessities, but this I am afraid will not effectually stem the increased cost of living. Since the war prices have risen in England by about 27 per cent.

There is one possible bright side to the war, and that may mean, from a sociological point of view, the introduction of many reforms. For instance, if it were so decreed that, in future, armaments, navies, and all the huge outlay incidental to sustained preparation for war, were to be materially curtailed, this would, to that extent, balance the expenditure on the present war. The employment of so much less capital in means of defence and aggression, would release a large portion of the national income for devotion to reproductive purposes.

One of the minor good economic results which may result from this war is the prohibition of the manufacture of vodka. This, it is generally supposed, was the cause of a great deal of misery in Russia—through the over-indulgence in this spirit much impoverishment amongst the peasantry was occasioned. In a lesser degree, the prohibition in France of absinthe may also be to the benefit of that nation; and, although England has not taken up any Government prohibition in respect to the manufacture of alcohol, still, the example of the King in abstaining during the period of the war, may have a very far-reaching effect upon the nation in permanently reducing any over-indulgence. Although this may not appear to be an economic point of importance, it has, in reality, a very great bearing upon the financial status of the people.

I have very briefly dealt with a few of the economic problems raised by the war, but my remarks have only touched the fringe of a very wide subject. Almost every aspect of the question is capable of broad treatment. The subject bristles with problems of a most serious nature. The calculations involved, and the human interests involved, are staggering in their magnitude. We can only hope that out of great evil some permanent good will result. The student of political economy has an important part to play, for we shall undoubtedly require the keenest intelligence and foresight in order to solve the grave problems that the future holds. Only a careful study of the problems before us will ensure that sound judgment and common-sense is brought to bear on these matters.

TRANSACTIONS OF SOCIETIES.

South African Institute of Electrical Engineers.—Thursday, April 15th: B. Price, President, in the chair.—"*Prof. Bergonie's chair for the treatment of obesity and heart trouble*": W. H. **Perrow.** The object of the chair is to impart to the patient muscular contractions similar to those produced by walking. The muscular contractions are set up to the same number as the beats of a metronome provided with dipping contact in mercury, and capable of being set to any required number of beats per minute.

Thursday, May 20th: B. Price, President, in the chair.—"*Fundamental principles involved in the lay-out of a telephone exchange system*": T. **Pearson.** The paper was devoted to a description of ground-work details, *e.g.*, the consideration of a central location, the determination of a suitable telephonic centre, and the establishment of subsidiary exchanges.

Thursday, June 17th: B. Price, President, in the chair.—"*Water power plants: with special reference to the power plants of the Rezende Mines, Ltd., Penhalonga, Southern Rhodesia*": H. **Wragg.** The Umtali River enters the Penhalonga Valley over a diorite dyke with a free fall of 380 feet. The water is led along a 1,500 yard flume with a capacity of 200 ft. per minute, and drives double 40-inch Pelton wheels. This Umtali River electrical scheme is in good order after 15 years' continuous work Seven miles to the north flows the Odzani River, in connection with which two power schemes have been installed. In scheme No. 1, 2,400 cubic ft. of water per minute are carried along a flume on a trestle bridge to three Pelton wheels. Scheme No. 2 takes in the water discharged from No. 1 Station, and the two Odzani systems together supply 25 motors with an aggregate of 1,600 h.p.

South African Society of Civil Engineers.—Wednesday, May 12th: R. W. Menmuir, A.M.I.C.E., Vice-President, in the chair.—"*Notes on railway construction in the Katanga, Belgian Congo*": E. A. **Browning.** A general description of the country and its typical features was given, together with an account of the labour conditions. The construction of the line had to be preceded by making a clearing through the forest, and a special feature of the earthworks was that necessitated by the enormous size of the ant-hills, which ranged up to 20 ft. in height, with a diameter of 60 ft. at the base. The removal of one such ant-hill involved the excavation of 1,200 tons of earth.

Wednesday, June 9th: R. W. Menmuir, A.M.I.C.E., Vice-President, in the chair.—"*Unit stresses in reinforced concrete; from a railway engineer's point of view.*" W. H. **Clark.** The author suggested that in testing the strength of concrete the stresses to be allowed for purely static loads should be determined, and that live stresses should be reduced to that basis by impact allowance. He proceeded to discuss what impact allowance added to the live load, should be considered as reducing it to an equivalent dead load. It was considered that reinforced concrete will be more used for railway works than in the past, though probably not as extensively as had once been imagined.—"*The parabolic reinforced concrete arch*": A. H. **Henderson** and Prof. A. E. **Snape.** The use of the parabolic form of arch considerably simplifies calculations. Various conditions were considered generally and in particular applications.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, May 22nd: Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., President, in the chair.—"*Notes on the practical testing of working cyanide solutions*": E. H. **Croghan.** The author showed that considerable diversity of results might be obtained in testing working cyanide solutions in consequence of lack of uniformity of practice in regard to the end point of titration. He suggested a discussion as to the most suitable methods for uniform adoption, and quoted his own practice in such cases.

SOME FEATURES OF THE RAND GOLD MINING INDUSTRY.

By W. A. Caldecott, D.Sc.

It is now twelve years since the writer submitted to the South African Association for the Advancement of Science a paper entitled, "The Development of Gold Extraction Methods on the Witwatersrand," and twenty-five years since his experience began of life and work on the Rand. During the years that have passed since 1903 the metallurgical progress made has been considerable and continuous, though its rate has varied. This has been in spite of industrial and seditious troubles and the present world-wide war, in which South Africa is involved, but which has not prevented the steady daily production by the mines for shipment to London of £100,000 worth of gold, the material basis of credit. Since 1903 the technical details of much of this progress has been ably reviewed at meetings of this Association by Messrs. J. R. Williams and H. A. White, and more recently by Professor G. H. Stanley. Under these circumstances, the author proposes to include in his review certain general considerations, which are not the less important, because in some cases their influence upon gold extraction is indirect.

The tabular statement on page 114 shows the main results of the operation of the Witwatersrand gold mines during the past twelve years, and is compiled from figures published by the Government Mines Department and Transvaal Chamber of Mines.

Year.	Tons of Ore crushed.	Gold Recovered Ozs.	Gold Recovered Value.	Percentage of World's Annual Output.	Average per Ton (2,000 lbs). Yield.		Working Cost.*		Working Profit.*		Dividends (including Sundry Revenue). Total.	Per Ton.†		Average Number of Workers. White.	Coloured (Non-European).
		Fine Gold.	£ Sterling.		s.	d.	s.	d.	s.	d.	£	s.	d.		
1903	6,071,908	2,832,346	12,031,037	17.9	39	8	24	9	14	11	3,334,347	11	0	11,214	58,703
1904	8,022,736	3,638,017	15,453,312	21.6	38	6	24	4	14	2	3,821,847	9	6	13,027	76,557
1905	11,160,422	4,706,433	19,991,658	25.6	35	10	23	6	12	6	4,754,349	8	6	16,227	131,036
1906	13,571,554	5,559,534	23,615,400	28.6	34	6	22	10	12	6	5,565,969	8	2	17,210	136,321
1907	15,523,229	6,220,227	26,421,837	31.1	33	11	20	10	13	3	6,962,420	9	0	16,755	155,214
1908	18,196,589	6,782,538	28,810,393	31.7	31	5	18	0	13	5	8,536,773	9	5	17,593	160,919
1909	20,543,759	7,039,136	29,900,359	32.0	28	11	17	1	11	6	9,310,751	9	1	20,625	168,311
1910	21,432,541	7,228,311	30,703,912	32.8	28	6	17	7	10	6	8,887,185	8	4	23,652	183,592
1911	23,888,258	7,896,802	33,543,479	35.4	27	11	18	0	9	7	7,763,086	6	6	24,708	189,912
1912	25,486,361	8,753,568	37,182,795	38.8	29	0	18	8	10	0	7,960,394	6	3	23,817	192,575
1913	25,628,432	8,430,998	35,812,605	38.3	27	9	17	11	9	6	8,205,199	6	5	23,104	184,266
1914	25,701,954	8,033,570	34,124,434	36.8	26	6	17	1	9	0	8,073,436	6	3	20,971	167,502

* Gold held in reserve, expenditure charged to capital account, interest on and redemption of debentures, and profits tax have not been taken into account in the working costs and profits. For various reasons the working profit shown is not in all cases the exact difference between the yield as shown and the working costs as shown. Thus, while the gold recovered from accumulated slimes is included in the yield, the profit therefrom sometimes appears in sundry revenue instead of in working profit. Again, while the yield is valued at a fixed rate per fine ounce, the rate applicable to the working profit is the actual realisable value of gold, which fluctuates slightly.

† The difference between working profit per ton and dividends per ton is accounted for by the fact that the working profit figure is the gross profit obtained, from which is deducted profits tax, amounts appropriated for capital expenditure, contributions to Miners' Phthisis Compensation Fund, debenture interest and redemption, etc., etc., while certain amounts are always carried forward by the mining companies from one financial year to another.

From that table certain conclusions are apparent:

(*a*) The tonnage of ore crushed has increased fourfold since 1903, and is still increasing.
(*b*) The total mining dividends attained a maximum in 1909, and the gold yield in 1912.
(*c*) The percentage which the Rand gold constitutes of the world's annual output has doubled since 1903, and is now equal to about three-eighths of the total.
(*d*) The yield, cost and profit per ton of ore have all decreased to about two-thirds of the 1903 figures, the present cost being somewhat more than two-thirds, and the profit somewhat less than two-thirds.
(*e*) Working costs per ton of ore were the same in 1914 as in 1909, but the working profit about one-fifth less in 1914.
(*f*) The value of the present average gold yield per worker on the mines is 9s. 11d. per day.

Working costs would doubtless be lower now than in 1909 but for heavy increased expenditure due to safety and hygienic measures in various forms, such as dust-allaying and ventilation underground, relief to disabled workers, expenditure due to industrial disturbances, and to the increased cost of mining supplies. As it is, the larger scale of operations and the continual advance in technical details promoting efficiency and economy have only served to offset the additional expenditure due to the causes stated. As regards the cost of supplies, it is considered by one school of economists that the greater the success attained in the exploitation of auriferous ores, the more does the increased production and abundance of gold tend to raise working costs through enhanced prices of mining supplies and commodities generally.

Though the average working costs during recent years are over 17s. per ton of ore, yet individual groups have obtained costs of under 14s.*, and individual mines under 12s.† per ton. This to a great extent has been due to the large scale of operations employed in such cases, and to the constant pressure caused by the necessity of profitably handling low-grade ore. If such differences are applied to the total ore tonnage of the Rand, the amount involved is nearly £4,000,000 per annum, and the fact that the foregoing relatively low costs have been achieved is of promise, inasmuch as similar conditions should in time induce a general lowering of costs to conform with lower average ore values, and thus prolong the life of the Rand by bringing within the region of profit much ore which at present cannot be profitably mined.

Reviewing generally the position as displayed by the figures in the table in conjunction with the evidence of the Transvaal Chamber of Mines presented to the Economic Commission in 1913, which forecasts the future decline of the gold-mining industry of the Witwatersrand, it might be concluded that this industry has attained its zenith, and that whilst possessing the vigour of maturity, it will gradually become a less important factory in South African and the world's affairs than hitherto.

* Report of Consolidated Gold Fields of South Africa, Ltd., for year ended 30th June, 1914, p. 23.

† *Ibid.*, p. 30.

But even if this were the case, the experience of California and Australia has shown that the influx of an enterprising population, and the money rendered available by the exploitation of the natural capital wealth of these countries in the shape of gold reefs, has so stimulated permanent agricultural and pastoral production that the annual value of these latter products now far exceeds that of the gold output at any time. The maximum gold production of California for one year was during 1852, and amounted to £17,000,000, whereas the annual value of farm produce at the date of the last Federal census was £27,500,000. The gold output of Australia for 1853 was £12,757,000 (mainly from Victoria), and for 1903 was £16,295,000 (mainly from Western Australia); whereas in 1911 the value of agricultural, pastoral, and dairy products was £108,606,000. The present paramount importance of the mining industry to South Africa, and the equal necessity for stimulating permanent agricultural development, are emphasised by the members of the Dominions Royal Commission, who, in their Third Report (p. 11), published in 1914, formulate the following conclusions:—

(*a*) That the purchasing power of South Africa, under existing conditions and pending more complete development of its agricultural resources, is dependent to a peculiar extent on the produce of its mines;

(*b*) That the prosperity, the maintenance, and the development on economic lines of the mining industry are therefore not merely matters of importance to the shareholders, or to the population of the mining centres in South Africa, or even to the Government of the Union, but concern the Empire as a whole; and

(*c*) That as mines are of the nature of wasting assets, the permanent prosperity of the country also demands urgently the further scientific development of its agricultural wealth.

Since the white population of the Rand is about one-sixth of the white population of South Africa, the importance of the mines as employers of labour is very great. Broadly, the mining industry spends yearly seven million pounds for white labour, five millions for coloured labour, and ten millions for supplies. In addition to the above, about three millions are expended yearly on head office costs, mining taxation, claim licences, directors' fees, etc., so that nearly 15s. out of every sovereign's worth of gold extracted is spent locally. The rates of pay on the mines, as compared with other parts of the country or of the world, are high. In the reduction works probably a majority of the workers have been brought up in South Africa, underground a great deal fewer, but all except a very small percentage of the mechanics are from oversea.* Various causes have

* In his recent report to the National Advisory Board for Technical Education in South Africa, Mr. Percy Coleman states:—

"The aim of all organisation of technical education in this country must be a very great increase in the employment of South African born white labour. To a remarkable extent constructive work of all kinds is carried out under the direction of foremen and managers from overseas by coloured and native labour, whose ability and quantity are rapidly increasing. In many towns one is assured that no skilled mechanic can be found who has been trained in South Africa, and yet the returns which employers and others have been good enough to send to the National Advisory Board show that openings are abundant and prospects excellent for workers who are prepared to undergo the necessary training."

been adduced for this last state of affairs, the chief reason being probably that the demand for skilled workers can be more readily supplied from among imported men than by training apprentices. Efforts are, however, being made to remedy this condition, since the existence of large numbers of an untrained rising white generation in South Africa—unable to compete economically in unskilled labour with coloured workers, or in skilled labour with immigrant artisans, or even with coloured artisans in other parts of the country—is a problem of very serious importance. As in most gold-mining communities, the average length of service underground in one mine is short, but in the reduction works this is not the case, and as an illustration of this fact, it may be mentioned that on one group during one year, out of 257 reduction works employees other than learners, there were only fourteen dismissals and twenty-eight resignations, so that the average term of service was over six years.* No doubt the desire of the mining companies to retain skilled and reliable workers by considerate treatment, leave allowances, facilities for recreation and other privileges, is largely accountable for this result, but in view of the migratory nature of a mining population, it is somewhat remarkable that such a condition has been attained. So far as ore treatment is concerned, the law precludes anyone from rising to the position of manager of a company who has not been engaged for three years in work underground†. The result is that most able and enterprising technical graduates prefer to engage in mining rather than metallurgical work in the hope of ultimately attaining a manager's position, and since the number of such men is strictly limited, the progress of ore treatment is not adequately advanced by the energy and capacity of this class. As elsewhere than on mines, the worker's success in competition is largely the resultant of will and ability, and the objective of the first decade of working life should usually be experience, matters of position and pay being considered as secondary until a later period.‡.

Although the Rand is often regarded outside its own boundaries primarily as a share-dealing centre, this business really affects its great industrial population and welfare only to a minor degree. Whilst the sale of shares serves as the readiest means of raising capital for mining enterprises, yet the share values of a producing mine are of comparatively little importance to the bulk of the population of the Rand and of South Africa. A poor mine pays wages and indirect taxation, and consumes supplies and maintains its workers in the same way as does a rich property, in proportion to its scale of operations. Since dividends mainly go overseas, a large low-grade property is of much

* Annual Report of the Consolidated Gold Fields of South Africa, Ltd., for year ended 30th June, 1913, p. 31.

† *Journal of S.A. Inst. of Eng.*, **13** (1915), 177.

‡ P. Cazalet: "The Position and Prospects of the Young Mining Engineer on the Rand," in *South African Mining Journal* Anniversary Number (1912).

greater value to the State, and supports a much larger proportion of the community than does a small rich mine. A mine crushing ore under 5 dwt. per ton in value contributes nearly half as much again of the indirect taxes included in working costs per ounce of gold recovered as does a 7½ dwt. mine. The value of the gold-mining industry to South Africa is peculiarly evident at the present time, when, but for our gold export, the whole country would have but little to send in return for its many million pounds' worth of imports in the shape of foodstuffs and manufactures.

The paper by the author previously referred to was written shortly after the ending of the South African War, when the mining industry had hardly recovered from a prolonged suspension of its activities. Large though the scale of operations was at that time, the scope of these has now greatly increased, and various possibilities foreshadowed in the paper are now routine actualities. Among these is the economic increase of the percentage recovery of the gold contents of the ore, then estimated at 90 per cent. The possibility of increasing this percentage to any desired figure by finer crushing of the ore, causing more perfect exposure of the gold particles, and more efficient cyanide treatment, was indicated; the use of tube-mills for finer crushing has now enabled the amount of gold lost per ton of residue to be reduced to one-quarter of the pennyweight per ton of ore, then stated to be the usual total residue value. At the present time, in a well-equipped and adequate modern reduction plant, and at a cost well under the value of 1 dwt. of gold, a total residue worth only about 1s. per ton can be profitably obtained,* which, on ore assaying 8 dwts. per ton in value, would be equivalent to an extraction of 97 per cent. This percentage would be capable of still further increase but for the consideration that "metallurgy" is the art of making money out of ores," and that the treatment operations involved must hence stop short of the point where any additional gold recovered would cost more to obtain than its value. Such limit is not, however, a fixed standard since a variation in the cost of any factor involved in ore treatment, such as labour, power, stores, or changes in local conditions, immediately raises or lowers working costs, and consequently the "economic limit" of extraction.

With reference to the improvements in metallurgical methods, detailed progress is constantly being made, which in the aggregate is of great importance, although a device or method merely "different" is liable at times to be mistaken for something "better." Radical improvements, however, occur seldom, and in the history of the Rand few can be reckoned as such beyond the application of the cyanide process, first for the leaching of sand, and subsequently for the decantation treat-

* Annual Report of the Consolidated Gold Fields of South Africa for the year ended 30th June, 1914, p. 23.

ment of slime; the application of the zinc-lead couple for the precipitation of gold from very weak cyanide solutions; the recovery of water for re-use direct from the overflow of the slime-collecting vats; the building of very large and relatively cheap plants composed of correspondingly large units grouped together to deal profitably with low-grade ore; the introduction of heavy coarse-crushing stamps with secondary re-crushing in tube-mills*; and the gradual improvement in simplicity and efficiency of pulp classification methods. The employment of vacuum slime filters has enabled a better extraction of the gold to be obtained from slime, particularly when relatively high in value, than the ordinary decantation process; and the use of scoop discharges in tube-mills materially increases their crushing capacity.† Although sand-filling is essentially an underground operation, yet the transportation on the surface as pulp of the sand residue employed has been greatly developed,‡ and problems such as the neutralisation of acid mine water underground with limestone crushed to the fineness of cement, and the allaying of dust from the sand dumps by covering with a thin layer of mud from natural clay or slime residue, are still engaging attention.§

A very small proportion of the numberless proposals for improvements in current ore treatment methods has proved of sufficient utility to fulfil the hopes of those who brought them forward. As a rule, most real advance has been of gradual growth and development,|| unsuited for protection by letters patent, and hence benefitting the mining industry in general rather than any individual. Besides proposals emanating from an imperfect knowledge of actual local working conditions, many schemes are merely inferior variants of common practice. Very often more discernment is required to realise the need for an improved process or device than ingenuity to supply the want. New proposals can only be safely adopted as an essential part of ore treatment after tests have been successfully and continuously carried out on a working scale for a considerable time. In the spread of technical knowledge and the advancement of metallurgical practice the Chemical, Metallurgical, and Mining Society of South Africa has played a very important part, and the eight thousand pages of its *Journal*, published during the twenty-one years of its existence, constitute a mine of information for everyone engaged in the extraction of gold from its ores. The price of gold being non-competitive, has facilitated the publication and discussion of current practice or proposed developments, and the realization of the obligation that each

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* *Journal Chem. Met. and Min. Soc. of S.A.*, **10**, 108, 358.

† W. R. Dowling: "The Use of Scoop Discharges in Tube-Mills," in *Journal Chem. Met. and Min. Soc. of S.A.*, **15** (1915), 214.

‡ *Journal Chem. Met. and Min. Soc. of S.A.*, **14** (1913), 119.

§ *Ibid.* **15** (1915), 91, 174.

|| H. A. White: "Evolution in Metallurgy," in 21st Anniversary Number of *South African Mining Journal* (1912), 59.

worker owes to his fellows of contributing to the common stock* his quota of information in return for the far greater amount which he has received from others has hitherto weighed with a sufficient number of those concerned to very fully justify the Society's activities for the benefit of the gold-mining industry.

The existence on the Rand of a number of groups under different controls has also been a factor in progress, since the friendly competition for better results, and the diversity of opinion and methods employed to attain this end, have prevented the paralysing effect upon varied advance, which extreme concentration of technical control might cause. At the same time the group system, embracing several mines in each group, allows the cost of trials to fall lightly upon individual mines, as well as affords a ready means of ensuring the prompt adoption of any improvement on all the mines of the group. The group system and organisation, which is more highly developed on the Rand than on most mining fields, facilitates the provision of capital for opening up new mines or extending the scale of operations on producing mines, as well as renders available for each mine a specialised technical staff, whose cost would be an unwarrantable expense for any individual mining company.

The scale of operations on the Rand may perhaps be best realised by a few concrete illustrations. For instance, the additional refining charge of one penny per ounce of bullion recently imposed on the Rand output by the London refiners amounts to about £40,000 per annum. The previous costs of transport, insurance and refining the Rand bullion production of about one ton daily amounted to about 1 per cent. of its value, or, say, £350,000 per annum. A penny (0.02 dwt.) per ton of ore increased or decreased working cost, or variation in gold extraction, is equivalent to £100,000 on the tonnage of ore milled yearly on the Rand. In a plant such as the Knights Deep, Limited, crushing 3,500 tons of ore daily, twelve times this weight in all is elevated and transported as pulp, and the gold precipitated daily from 1¾ million gallons of gold-bearing solution. A slime charge of four hundred tons of solids with sufficient solution to form a fluid pump is pumped within an hour to make room for a succeeding charge, and in general, cheap and speedy transport of solids, fluids and pulp constitutes one of the main factors in the efficient and satisfactory operation of a modern reduction plant.

A feature of the development of ore treatment, which has not been generally realised, is the great decrease in the capital cost of reduction plant. Plants erected in 1903 cost about £215 per ton of ore treated per working day, which was much less than previously; but the increased scale of operations, larger size of all units—stamps, tube-mills, vats, pumps, and piping—and simplicity of design have reduced the cost in recent years

* Dr. Jas. Douglas: "Secrecy in the Arts," in *Proc. of Amer. Inst. of Mining Eng.*, **38** (1907), 455.

to about £107 per ton for a plant crushing, say, 3,000 tons per working day.* In the older plants much of the advance made during recent years in economy and efficiency has been secured by application of the foregoing principles, which has frequently involved elimination of existing devices and appliances. Among these are the entire elimination of stamp-mill amalgamated plates,† the substitution of a few large steel cone diaphragm classifiers for existing nests of numerous small pyramidal wooden spitzkasten,‡ and the continuous collection of sand by vacuum sand filter tables,§ thus avoiding the cost of sand collecing vats for drainage and storage only. At the present time the process of application and of full utilisation of the knowledge already gained is more pronounced than any apparent impending new developments, though minor advances are continually in progress.

In considering the local conditions of gold extraction, to the prime factors of continuity of large scale operations, the cheap cost of coal for power, a healthy climate and accessible locality, must be added the simple nature of the banket ore, and its amenability to amalgamation and cyanide treatment. Consisting, as the ore essentially does, mainly of silica with some combined silicates and about 3 per cent. of pyrite, its constituents offer few difficulties in treatment, and the chemistry of the processes involved has been worked in its essentials.‖ The possible greater compactness due to greater compression at increased depth merely involves somewhat finer crushing, though in no case has the proposal, based on experience on other fields, to all-slime the ore in place of crushing to fine sand and slime been found either necessary or economically desirable. On certain mines on the Eastern Rand portion of the gold appears almost uniformly diffused in an extremely fine state of division throughout the siliceous matrix, and in such case very fine, though leachable sand, is desirable. Similarly, the various costly attempts in the past to concentrate out the bulk of the gold into a rich pyritic production of small weight and to discard a valueless tailing has proved futile, since the gold and pyrite are not proportionately distributed in the ore, and hydraulic classification for the re-crushing of the tailing pulp ensures the proportionately finer reduction of the specifically heavier pyritic particles, which their value warrants. Attempts, accompanied by considerable expenditure, for rapid continuous treatment of the ore as one product, or of slime, have likewise failed. This was mainly because a considerable time is required to dissolve the gold particles in banket, and to separate the gold-bearing

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* Chairman's speech at Simmer Deep Meeting, 18th March, 1910; also "Rand Metallurgical Practice," **2**, 291, 337.

† *Journ. Chem. Met. and Min. Soc. of S.A.* **11** (1911), 414.

‡ "Rand Metallurgical Practice," **1**, 99.

§ *Journ. Chem. Met. and Min. Soc. of S.A.*, **10** (1909), 43.

‖ W. Bettel: "The Cyanide Process on the Rand," in 21st Anniversary No. of *S.A. Mining Journal*, (1912), 274.

solution from residual slime, the power and maintenance costs of maintaining large tonnages of pulp in motion for long were excessive, and the ordinary methods commonly employed as a result of a quarter of a century's experience and development have gradually attained a degree of economy and efficiency which are difficult to rival.* As everywhere with every ore, the best method is that which conforms most closely with the characteristics of the ore, and utilises most fully local conditions. Another method which has been practised on a working scale is the use of a dilute cyanide solution in place of water for crushing, which is frequently associated elsewhere with the treatment of silver sulphide or gold telluride ores. In the case of banket ore, however, this procedure involves the abandonment of a cheap and simple means of recovering half to three-quarters of the gold in the ore, and necessitates a much larger cyanide plant and more prolonged and expensive cyanide treatment. In addition to the foregoing objections, there is liability to loss of gold-bearing cyanide solution, and difficulty in obtaining accurate screen values. The retention of amalgamated plates, when crushing with cyanide solution, results in their gradual corrosion, and the deposition of the dissolved copper on the zinc shavings.†

The importance of good classification upon crushing so as to prevent oversize particles escaping from the crushing plant has already been referred to; but the necessity is no less for ensuring proper separation of sand and slime, so that each may receive the cyanide treatment by leaching or settlement to which it is adapted, and in order that the sand residue be ultimately well suited for mine filling. The presence of either product in appreciable quantities in the other interferes with the extraction, slime in sand causing non-permeable sand charges, and sand in slime causing pump wear and slow dissolution of gold in slime charges. At the present time a tailing pulp classifier should yield a slime overflow, of which 99 per cent. passes a screen of 200 holes to the linear inch.

Among the features of ore treatment practice, in which progress has been much marked, is the increased weight of stamps, and their duty in tons of ore crushed per 24 working hours. In 1903 a 1,250 lb. stamp with a 5-ton duty was considered to be doing good work with fine screening, whereas most recently erected stamp mills have been equipped with 2,000 lb. stamps, giving a 20-ton duty with coarse screening up to ½-inch aperture. The number of stamps installed on a mine has therefore long ceased to be any criterion of the tonnage of ore crushed monthly. This advance has been rendered possible by the use of tube-mills for re-crushing the coarser particles in the screen pulp, and has great advantages both in saving capital expenditure and operative crushing costs. In a modern plant

* Letter by F. L. Bosqui, in *Mining and Scientific Press* of 2nd May, 1914, and in *S.A. Mining Journal* of 6th June, 1914.

† E. L. Bateman in *Metallurgical and Chemical Engineering*, p. 672, Dec., 1913; and *S.A. Mining Journal*, p. 469, 10th January, 1914.

about two-thirds of the crushing is done in tube-mills, of which about three hundred have been erected on the Rand, having a crushing capacity of over a million tons of ore monthly. In ordinary battery practice, reduction of the ratio of water to ore, combined with high stamp duties, has greatly decreased the cost of pulp elevation and return water pumping costs, whilst the lesser volume of pulp has likewise decreased the classifier capacity necesary per ton of ore crushed. Owing to the tube-mill hydraulic classifiers determining the size of particles leaving the crushing plant instead of the aperatures of the battery screen, exactitude of the latter has become of minor importance. Grading analyses of various crushed ore products have become as much routine tests as are assays, in view of the fact that percentage of gold extraction is a function of crushing, whilst the relative crushing capacity of stamps and tube-mills is determined from grading analyses on the "nominal crushing unit" system.* In cyanide practice the influence of temperature upon the rate of slime settlement and of gold precipitation upon the lead-coated zinc shavings has been fully realised. The temperature of mill service water and cyanide solutions is therefore regularly recorded, and artificial heating employed in winter where economically practicable.

Another development which has become generally accepted in Rand reduction works is the system of circuits, whereby oversize ore particles are returned for further comminution, or water and cyanide solution for re-use. A reference to a flow-sheet diagram† will show that in addition to the tube-mill circuit and the mill service water circuit, both sand and slime solutions and residue discharge trucks have their own circuits, with the result that only the ore passes through the plant, carrying with it to waste, when discharged as residue, a certain amount of water in the form of dilute poor cyanide solution. This circuit system is largely the result of a limited water supply, and of the flat or gently sloping mill sites on the Rand, and is a distinct variation from the steeply inclined mill site in favour under other conditions, where the ore descends by gravity through the various stages of treatment, and the final tailings or residues are disposed of in a creek at the foot of the plant.

The author's sincere thanks are due to Mr. D. W. Rossiter for furnishing much of the statistical data contained in this paper.

Brevium, a New Element.—Uranium-X consists of two elements, Uranium-X_1 and Uranium-X_2, with half-periods of 24.6 days and 1.15 minutes respectively. To the latter the name Brevium has been given: it is a near analogue of tantalum, and occupies the last line in the fifth group of the periodic system.‡

* "Rand Metallurgical Practice," **1**, 136-7.
† "Rand Metallurgical Practice," **2**, 6, 7.
‡ *Journ. Chem. Soc.* (1915), 108, Abs. [2], 665.

CONTRIBUTIONS TO THE CHEMISTRY OF THE SOYA BEAN.

By Professor PAUL DANIEL HAHN, M.A., Ph.D.*

From time immemorial the soya bean has played a very prominent part in the household of the Eastern Asiatics; in fact, it is next in importance to rice. It is almost unthinkable in Japan that a meal could be completed without the soya bean figuring in the menu in some form or other. The soya bean, consisting principally of fat and albuminoids, is the very complement to the starch-containing rice, the staple food in Japan. China is supposed to be the home of the soya, where it has been under cultivation for over 5,000 years.

About thirty years ago the soya began to occupy a place in the world's trade. Owing to the ever-increasing demand from purveyors for vegetable fats and oils, the English oil-mills have made great use of the soya bean, which contains about 20 per cent. of oil. In 1908 not less than 200,000 tons were imported into Europe from China, and in 1909 over 500,000 tons.

During recent years many publications on the botany and the cultivation and practical uses and applications of the soya bean have appeared, of which one deserves special mention, giving a full account of the numerous methods of preparing the soya bean for consumption.†

In the *South African Agricultural Journal* articles on the soya bean have also been published, and these have induced some zealous students to undertake certain experiments and investigations bearing upon the soya, grown in South Africa.

Two kinds of soya beans were available for these experiments, a large white bean, directly imported from Manchuria, and small black bean grown on a farm in the Cape Flats.

THE LARGE WHITE VARIETY.

This sample of soya was by no means fresh, being at least three years old at the time when the experiments commenced. The amount of moisture was therefore much less than that of the fresh beans subsequently obtained.

The beans were found to contain:—

Moisture.	4.80	per cent.
Inorganic Constituents (ash) .	4.22	,,
Organic Constituents	90.98	,,

* Nearly all the analyses given in these notes were made by the late Mr. Morris Anderson, B.A., who died of fever in France while a member of the Royal Army Medical Corps. Mr. Anderson was an enthusiastic and successful student of science, and his untimely death in the service of his country is mourned by none of his friends more deeply than by the writer of these contributions, which have been compiled from the notes left by his departed friend.

† Li-Yu-Ying: "Le Soya, sa culture, ses usages alimentaires, thérapeutiques, agricoles et industriels." Paris (1912).

The ratio of inorganic to organic constituents is accordingly 1 :22.82.

The composition of the air-dried beans was:—

Water	4.80	per cent.
Albuminoids	34.07	,,
Nitrogen-free Extract	27.99	,,
Ether Extract (Oil)	17.68	,,
Crude Fibre	11.17	,,
Ash	4.23	,,

This analysis does not afford any fresh information on the soya bean; it only confirms that the soya is very rich in oil and albuminoids. Numerous experiments carried out in physiological institutions prove that the constituents of the soya bean are most digestible.

The composition of the ash of the soya bean illustrates in a striking way that the requirements of the plant, so far as plant food is concerned, are principally potash and phosphatic manures.

The results of the analysis of the ash of the largest white soya bean were as follows:—

Silica	5.56	per cent.
Calcic Oxide	5.60	,,
Phosphoric Oxide	30.46	,,
Sulphuric Oxide	3.71	,,
Potassic Oxide	50.36	,,
Sodic Oxide	2.41	,,
Ferric Oxide	.58	,,
Magnesic Oxide	1.40	,,

In the village of Swellendam a small plot of ground was planted with soya beans of the same sample; it was a fairly rich alluvial soil. The beans were planted towards the end of September, 1914, and harvested at the beginning of February, 1915. During the period of growth they were twice irrigated. They grew into shrubs of five feet high, and the weight of the air-dried plant was on an average 6 lb. The average number of beans in pods was three, and the weight of 100 beans 17.438 grammes, corresponding to 2.7 grains per bean.

The beans obtained from these plants grown at Swellendam contained:—

Albuminoids	25.156	per cent.
Oil	18.783	,,

The other parts of these plants also contained much albuminous matter, and supply an excellent fodder for horses and cattle.

The pods contain 2.63 per cent. of albuminous substance.

The hay contains 4.02 per cent. of albuminous substance.

The leaves contain 10.40 per cent. of albuminous substance.

The Small Black Variety.

The beans of the small black variety of soya, which were experimented with, were found to contain:—

Moisture	11.35	per cent.
Inorganic Constituents (ash)	4.97	,,
Organic Constituents	83.68	,,

The ratio of the inorganic to the organic constituents in the small black beans is therefore 1:16.83.

The air-dry black soya beans were found to contain:—

Albuminoids	29.50	per cent.
Oil	11.60	,,

The results of the analysis of the ash of this variety of soya also demonstrate that phosphatic and potash manure is principally required by the soya. The results of the analysis made of the ash of the small black variety of bean were as follows:—

Silica	2.93	per cent.
Calcic Oxide	5.13	,,
Phosphoric Oxide	38.36	,,
Sulphuric Oxide	3.09	,,
Potassic Oxide	45.18	,,
Sodic Oxide	.40	,,
Ferric Oxide	.40	,,
Magnesic Oxide	4.50	,,

Of this small black variety of the soya bean also some were planted on a plot of ground on a hill at Swellendam at the same time as the white variety was planted, and was also harvested at the same time as the white variety. The soil of this plot was poor virgin soil ("*Nabank*"). Although the ground was not irrigated during the period of growth, the yield of beans was very large. The average height of the mature plant was 3 feet 6 inches, and the average weight of the air-dry plant was 1.83 lb. The average number of beans in a pod was two to three, and the average weight of 100 beans 8.664 grammes, corresponding with 1.34 grains per bean.

The beans obtained from these plants grown at Swellendam contained:—

Albuminoids	26.95	per cent.
Oil	17.43	,,

The pods contained 2.187 per cent. of albuminoids.

The hay contained 4.37 per cent. of albuminoids.

The leaves contained 11.59 of albuminoids.

THE MINERS' PHTHISIS OF THE RAND.

By Wilfred Watkins-Pitchford, M.D., F.R.C.S., D.P.H.

The gold-mining industry is at the present time the most important industry of South Africa. Like so many of the principal industries of the world, it has its special industrial disease, and the nature and characters of this particular disease cannot fail to be of engrossing interest to all Africanders of liberal mind.

The limitations of the space at my disposal preclude any exhaustive treatment on the subject; I propose, therefore, to omit all reference to the statistical and economic sides of the matter, and to review briefly the salient points in the causation of the disease, and the essential characters of the changes which it produces in the lungs.

Considerable misunderstanding exists as to the exact scope of the terms pulmonary silicosis and miners' phthisis. In general it may be said that although the terms are synonymous, the technical discrimination lies in the fact that pulmonary silicosis, or briefly silicosis, does not become miners' phthisis until the affected lungs are invaded by the tubercle bacillus.

Pulmonary silicosis implies an excess of silica in the lung tissues, and the direct effect of this excess of silica is to produce an overgrowth of the connective tissue of the organ, and thus impair its function. The condition so established is rarely fatal in itself; the fatality is usually consequent upon an infection of the damaged lungs by the tubercle bacillus.

In illustration of the fact that silicosis by itself is not necessarily a fatal disease, I may state that I have recently examined the lungs of a man who worked underground for eight years, when the conditions of labour were very bad, and who, as the microscope showed, developed silicosis during this time. He then quitted his underground occupation and, seven years afterwards, died of the ordinary type of pneumonia to which we are all liable.

The infection of the silicotic lung by the tubercle bacillus gives rise to a form of phthisis (miners' phthisis), which differs from the ordinary form of consumption in two important respects. In the first place the tuberculous infection very rarely, if ever, spreads to other organs of the body, and, secondly, the infection is very rarely communicated to other people—unless their lungs also have been previously damaged by silicosis.

Pulmonary silicosis is caused by the inhaling of air in which particles of silex are floating, and the forced respiratory movements which occur during severe muscular exertion facilitate the entrance of the dust-laden air into the deeper air passages. All the silica detectable in lung tissue has entered the body with the inspired air; the swallowing of siliceous dust, *i.e.*, taking it into the stomach, is incapable of producing pulmonary silicosis. Although silica is so abundant in the bodies of certain

plants, it is not an original component of the bodies of the higher animals. The lungs of an infant do not contain any silica, but as life advances the amount of this extraneous material gradually increases, and by the time adult life has been reached it forms from 10 to 15 per cent. of the ash. In contrast with this figure the analyses of Dr. J. McCrae show that the ash of a miner's phthisis lung yields from 30 to 50 per cent. of silex.

Anyone who engages in a dusty occupation is liable to the accumulation of minute particles of foreign matter in the tissues of the lung, and to this condition the generic name of pneumonokoniosis is applied. Special names are given to the condition when it is due to particular varieties of dust: thus particles of iron and iron oxide give rise to siderosis; if the dust be that of coal, the condition is one of anthracosis; clay dust produces aluminosis, and dust which is mainly composed of siliceous particles is responsible for silicosis.

It is a noteworthy fact that, contrary to popular belief, most varieties of dust, even of mineral dusts, are not acutely harmful. Careful enquiries have shown that there is no industrial phthisis amongst operatives who habitually inhale the dust from coal, chalk, plaster of Paris, bricks, tiles, emery, slag-wool, glass, and Portland cement. The dust which, before all others, possesses power for evil is the one to which we have already referred, *viz.*, siliceous dust. It is siliceous dust (the particles being of silica and not silicate) which is responsible for that industrial disease which appears in different industries under such names as grinders' rot, potters' rot, stonemasons' rot, and miners' phthisis.

It was formerly thought that needle-grinders and flour-millers developed their phthisis in consequence of inhaling particles of steel and flour respectively; it is now known, however, that the grindstone, and not the material ground, is responsible for the trouble. The old-fashioned grindstone is made of French buhrstone, millstone grit, or other very hard sandstone, and it is the refacing of the grindstone or the running of it in a dry condition which has, in the past, been so prolific a cause of industrial phthisis.

Flint is practically pure silica, and it is the use of finely ground flints in the ceramic industries which has been responsible for the phthisis death-rate in the potteries.

Granite contains about 30 per cent. of silica, and the harder varieties of sandstone contain much more; it is amongst the men who cut such hard siliceous stone that stonemasons' rot is prevalent. Marble-workers and cutters of limestone no not appear to be materially more liable to phthisis than other peoeple.

Quartz is pure silica, and the dust which is primarily responsible for the production of gold-miners' phthisis is that which is derived from quartz, and the siliceous rock known as quartzite.

An interesting confirmation of the specifically injurious in-

fluence of silex dust has been obtained amongst the flint-knappers of Brandon, by Dr. E. L. Collis, H.M. Inspector of Factories. When the surface of a flint is flaked off by a blow a fine smoke of siliceous dust arises, and the worker who is exposed to the repeated inhalation of such dust is unusually liable to develop the form of phthisis known as knappers' rot. Flint-knapping, as Dr. Collis remarks, is probably the oldest of the world's industries; it is an interesting speculation as to the extent to which our troglodyte ancestors suffered from silicotic phthisis.

True miners' phthisis is found in Great Britain among the tin miners of Cornwall and the ganister miners of Yorkshire and elsewhere. It is, however, very encouraging to find that the mortality from this cause amongst ganister miners has now almost disappeared, owing to the enforcement of common-sense precautions.

Ganister is an extremely hard sandstone, containing from 97 to 98 per cent. of silica. It is ground to powder, mixed with lime water, and compressed into fire-bricks for lining steel converter-furnaces.

The gold-bearing reefs of the Rand are a conglomerate of quartz pebbles in a siliceous matrix, and this conglomerate lies, for the most part, embedded in extensive deposits of quartzite. The gold-bearing conglomerate contains about 86 per cent. of silica, whilst the quartzite, which has to be tunnelled through to reach and expose the reef, contains an even higher proportion It is the drilling and blasting of such deposits which gives rise to the dangerous siliceous dust.

A description of the clinical features of gold-miners' phthisis is unnecessary here; from the physiologist's standpoint, however, it is of interest to note that the outstanding feature of the disease is a progressive loss of the normal elasticity of the lung. The normal lung, being elastic, is capable of following the movements of expansion and contraction of the chest walls. The lung of the silicotic patient, on the other hand, is increasingly resistant to inflation by the current of inspired air, and the ultimate result is that as the lung cannot follow the chest wall when this expands, the chest wall becomes more and more fixed in the position of expiration. The most forcible inspiratory efforts eventually fail to elevate the chest wall against the pressure of the atmosphere.

A striking and apparently consistent peculiarity of the silicotic lung, as found on the Rand, is the deposit in it of extraneous pigment in conjunction with the extraneous silica; the result of this peculiarity is that the degree to which silicosis has advanced can be roughly estimated by the extent and character of the deposits of pigment in it. The normal lung has but very little extraneous pigment in it; in the early stages of silicosis we find very numerous, small, discrete islands of pigmentation; in the middle stages these islands have become so numerous that many of them coalesce with their neighbours, and thus give rise

to a sort of ragged network of pigmentation; in the advanced stage the whole tissue is more or less uniformly pigmented.

The onset of infection by the tubercle bacillus, which may occur at any stage of silicosis, is usually indicated by the appearance of small areas of light grey fibrous tissue of very characteristic appearance and structure. As time advances these areas of new, grey tissue are liable to undergo necrosis—that is, local death and disintegration—thus giving rise to cavities or to collections of fluid, which are dark grey or almost black in colour owing to the pigmented particles which have now been liberated from the dead tissue.

Silica is a very hard and brittle substance, and when crushed breaks up into a powder of minute angular fragments, many of which are elongated. We are all familiar with the conchoidal fracture of flint, and it is interesting to remark that traces of this characteristic fracture are also to be found in the microscopic fragments which are given off when siliceous rocks are abraded by drilling or shattered by blasting.

If we make an ordinary microscopic examination of a section of silicotic lung, we shall find evidence of fibrosis—that is to say, a great increase in the number of connective-tissue cells normally present, and an encroachment by these cells upon the cavities of the air vesicles. We shall also find that the collections of pigmented matter, which are so conspicuous to the unaided eye, have been first laid down around the smaller blood vessels and air tubes. The pigmented matter itself we shall find to consist of carbonaceous particles, many of which, when viewed under higher powers, are found to be contained within the bodies of phagocytic cells. When we come to look for fragments of silica, however, we shall fail to see them, unless we are very experienced, for they are translucent, and do not hold the stain with which the section is coloured. In order to make the siliceous particles visible, we must first polarise the light, and then view our section through an analyser; with the Nicol prisms crossed most of the particles of silex stand out as bright specks and spicules. We shall now be enabled to measure the particles with a micrometer, and to discover the fact that they are of very small size.

The peculiar areas of light grey tissue, which usually indicate the onset of tuberculous infection, are found, by microscopic examination, to enclose in their meshes collections of pigment and mineral fragments. The silica among these fragments will not become obvious, of course, until we polarise the light and put on the analyser.

It is probable that all the fragments of silex found in the lung tissue have first been taken up within the bodies of living leucocytes and other wandering cells, and then conveyed by these sightless porters along the lymphatic channels of the organ. These wandering cells are unable to transport particles, which are much larger than themselves, and it is this fact which ex-

plains and justifies the conclusion that it is only fine siliceous dust which is dangerous to the lungs.

We have thus seen that the miners' phthisis of the Rand is due primarily to the breathing of air carrying minute siliceous particles, and secondarily to an infection of the damaged lung by the tubercle bacillus. It is therefore obvious that the suppression of the disease will be obtained by action in two directions—preventing the workers from inhaling the dust, and detecting and excluding from the mines all those who are expectorating the tubercle bacillus.

I shall not make more than a brief reference to the principle involved in the various precautions now adopted to prevent the worker from breathing dust.

Machine drills, the attendance on which has been such a prolific cause of the disease amongst hard-rock miners both here and in other countries, are now so constructed that they automatically deliver water along a channel in the drill into the hole which is being excavated; the dust produced by the abrasion of the rock is thus immediately converted into a very thin mud. A further improvement in this type of machine would be a device which could be fixed around its neck to collect the water escaping from the hole, and enable the machine to be used for drilling overhead rock without inconveniencing the worker by the falling mud. Such a device would probably take the form of a deep-guttered tray, or funnel, fitted with a drainage tube to conduct the slime into a bucket or other receptacle.

Dryness of the underground workings, paradoxical as it may appear, is inimical to health. Whilst the flinty powder, produced by drilling and blasting, is held in the form of mud or slime, it is innocuous; the danger arises when it is allowed to dry on the hands, clothing, implements, or any other surface which is liable to be disturbed. The past experience of the pottery industry in this matter is very instructive. What appeared to be one of the most potent causes of potters' rot, in the past, was the handling of the dry biscuit ware, from the surface of which a fine siliceous dust was liberated when it was touched with the hands. As the biscuit ware could not, of course, be wetted, this particular source of danger has been removed by the aid of powerful extraction fans.

Blasting is an operation which inevitably liberates a large amount of dust, mainly, of course, from the shattered rock, but partly from dust-covered surfaces which have been allowed to become dry, and which are disturbed by the concussion. The amount of dust liberated into the air of the underground workings by blasting is greatly reduced by the use of water-blasts, sprays, atomisers, water-screens, and other devices. Despite all such expedients, however, a fine, impalpable, and often invisible dust hangs in the air for several hours afterwards. The worker can be prevented from inhaling such air either by secur-

ing its removal by active ventilation or by forbidding all entrance to the particular working for a sufficient length of time.

It is of practical interest to note that even the most efficient respirator yet devised is incapable of arresting the fine, siliceous dust, which is the essential factor in pulmonary silicosis.

The other direction in which miners' phthisis is being combated is the detection and exclusion of those workers, who are expectorating the tubercle bacillus, and who are therefore active distributors of infection. Investigations in this matter are being pursued by more than one administration, but I am not free to make any statement, at the present time, concerning certain conclusions which appear imminent.

Bearing in mind that pulmonary silicosis has been very prevalent amongst flour-millers and metal-grinders, as well as amongst hard-rock miners, the following facts are of interest. The substitution of steel rollers for grindstones in the milling industry has practically abolished phthisis. Twenty years ago friendly societies would not accept millers as members, but no objection to their membership is now heard of. The steel-grinders of Solingen, during the year 1885-95, died at the rate of 20 per 1,000; precautions were adopted, with the result that, in 1905, the mortality has fallen to 10 per 1000.

Amongst miners engaged in quartz-rock mines we notice that those of the Waihi mines of New Zealand, where precautions against inhaling dust are enforced, are much less affected with pulmonary disease than the workers in less favoured mines of the same country. In the ganister mines of Yorkshire the mortality from phthisis had been "officially" reduced 15 per cent. between the years 1900 and 1912; and upon visiting these mines in September, 1914, I found, to my surprise, that the workers admitted that the disease had been practically abolished from amongst them. Turning now to the Witwatersrand, we find that the President of the Chamber of Mines has recently announced that the applicants for relief under the Miners' Phthisis Compensation Act have decreased 50 per cent. since the promulgation of the measure in 1912.

The proposition of abolishing miners' phthisis from the Rand is an entirely feasible one, provided always that the worker and the management co-operate loyally in the common cause. The degenerate and inhuman sentiment revealed in the dictum of "my class, right or wrong," is antagonistic to all communal progress; such an influence can only serve to still further postpone the time, desired of all true scientists, when a man shall be appraised, not by his services to his class, but to humanity.

NOTES ON THE CHEMICAL COMPOSITION OF KARROO ASH.

By Charles Frederick Juritz, M.A., D.Sc., F.I.C.

At the joint meeting of the British and South African Associations for the Advancement of Science, in 1905, a paper by Mr. E. H. Croghan, F.C.S., was read, entitled "A fuel of the Midland Districts of South Africa." The paper was subsequently printed in full in the proceedings of the meeting published by the South African Association,* but for the present purpose it will suffice to quote the summary thereof printed in the British Association Report.† This summary is as follows:—

> The region known as the Midland Districts is dry and treeless, with a scarcity of rainfall. The better part of this region is suitable for sheep-farming, being sparsely covered with bushes, the foliage of which constitutes the chief food of sheep and cattle. These bushes are very hardy, and have an enormous root system, penetrating to a great depth. They are of great nutritive value, as they contain a comparatively large quantity of digestible carbohydrates, principally starch. These carbohydrates are associated in the plant system with potash compounds; therefore we also find a large quantity of potash in sheep excreta. This manure accumulates in considerable quantity in the kraals (a sort of paddock near the homestead). The farmer has no use for this manure as such, because he has no water for irrigation, and gets a very indifferent supply from his wells. In some parts of the sheep districts it is a well-known fact that the drought is often so severe that the lambs are killed to save the ewes. The farmer therefore uses the dung only as fuel. He has it dug out and cut into bricks, somewhat resembling those made of spent tan, which in some continental countries are similarly used as fuel. The ashes are thrown aside, and frequently accumulate as small mounds near the homestead.
>
> These ash-heaps, as well as the manure itself, are of great economic value, more particularly for heavy, clayey soils. The Cape farmer obtains a fair supply of guano from the Guano Islands along the coast, and if he were to supplement this with ashes of sheep dung, thus supplying the necessary potash (guano being principally of a nitrogenous and phosphatic nature), he would secure an excellent manure for raising all kinds of grain and root crops, especially potatoes. For industrial or domestic purposes these ashes may be used for the production of potassium carbonate, which can be employed in making soft-soap, since

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* *Addresses and papers read at the joint meeting of the Brit. and S.A. Assns. for Adv. of Sc.* (1905), **1**, 237-246.

† *Rept. Brit. Assn. for Adv. of Sc.*, South Africa (1905), 373, 374.

fat, tallow, and beef-suet are also by-products on most farms. As potassium carbonate is, so to speak, the starting-point in the production of all potash compounds, its uses are many, one being the formation of cyanide of potassium, employed largely in gold extraction.

To the above excellent summary of the conditions under which Karroo ash comes into existence, it is not necessary to add any further explanation. Mr. Croghan, in the course of his paper, presented a series of twenty-five chemical analyses of the sheep or kraal manure, from which the Karroo ash is derived. Of the samples analysed, 14 were produced within the Cape Province, and 11 in the Orange Free State. In each case the manure was allowed to become air-dry before being analysed, and it will serve a most useful purpose to tabulate the following summary of the results so arrived at:—

	Moisture.	Organic Matter.	Ash.	Potash.	Lime.	Phosphorus Pentoxide.	Nitrogen.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Cape Province—							
Maximum . .	10.50	71.02	55.88	5.86	4.94	1.28	1.40
Minimum . .	5.34	38.15	21.68	1.23	2.20	.45	.55
Average . . .	7.87	55.58	36.55	4.02	3.58	.79	1.14
Orange Free State—							
Maximum . .	9.32	66.21	61.47	5.03	4.06	1.04	1.68
Minimum . .	5.32	30.36	26.96	2.13	1.34	.38	1.12
Average . . .	7.49	50.30	42.11	3.64	2.68	.77	1.33

Calculated on the *perfectly* dry material the above averages become:—

	Organic Matter.	Ash.	Potash.	Lime.	Phosphorus Pentoxide.	Nitrogen.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Cape Province	60.33	39.67	4.36	3.89	.86	1.24
Orange Free State . . .	54.37	45.52	3.93	2.90	.83	1.44

Basing the assumption on these figures, the average Karroo ash, if *perfectly* pure, would contain the following percentages:—

	Potash.	Lime.	Phosphorus Pentoxide.
Cape Province	10.99	9.81	2.17
Orange Free State	8.63	6.37	1.82

The better quality of the ash from the Cape Province, as well as its smaller proportion in the unburnt manure, was probably due to the Orange Free State samples having been more largely mixed with sand than those from the Cape. How curiously such admixtures affect the quality of the manure when burnt we shall see later on.

Mr. Croghan found the following *maxima* and *minima* percentages in the ash of the manures analysed by him:—

	Potash.	Lime.	Phosphorus Pentoxide.
	Per cent.	Per cent.	Per cent.
Cape Province—			
Maxima	18.57	16.82	3.50
Minima	3.56	4.53	1.32
Orange Free State—			
Maxima	16.50	14.16	2.95
Minima	3.74	3.66	1.20

The wide variations between these maxima and minima point to a considerable variation in the purity of the several kraal manures examined. Some of them must have been considerably mixed with sand. And the consequence of such admixtures is that the manures so contaminated yield ash of very inferior quality, even when carefully burnt under all the advantages of a chemical laboratory. When roughly burnt on the farm, an additional variation is introduced, depending on the degree of completeness to which combustion is carried; and after the manure has been burnt, and the ashes are collected, a further contamination may arise by scraping earth together with the ashes.

So we see that Karroo ash is subject to three sources of variation of composition:—

1. The original kraal manure may be more or less mixed with sand.

2. The manure may be incompletely burnt, and may therefore contain much unburnt carbon or charred material.

3. The ash, after burning, may have been mixed with earth.

It may be that, either by force of circumstances beyond control, or through carelessness, all three sources of contamination may operate in one and the same case, and then we have a very inferior Karroo ash indeed; and, on the other hand, the greatest care may be exercised in each process, and combine to produce an excellent ash. What the result of repeated incorporations of unburnt material and sand at each of the *three* steps indicated above may be, we can imagine when we find that, in spite of professional care exercised in the chemical laboratory when burning the manure and collecting the ash, so much earth had got incorporated with the original manure as to lower its quality to that of the minima for the Cape Province in the last of the above tables, for, as a matter of fact, these three percentages belong to one sample, and represent the ash of what was evidently a very impure kraal manure from the farm Sekretaris, in the Kimberley district.

Here I take leave of Mr. Croghan's work for a while, in order to turn to some investigations carried on at intervals during

a long stretch of years in the Government Chemical Laboratory in Cape Town. The object of those investigations was not to ascertain what kind of an ash may be produced in the laboratory from a manure that originally might have been either excellent or poor, but to gain reliable information with regard to the usual composition of Karroo ash as prepared, from start to finish, by the farmer and his men, on the farm.

It was as long ago as 1890 that the first steps in this investigation were taken. Samples of Karroo ash were obtained, during that year, from the neighbourhood of Grahamstown, in the Albany Division, from the farm Tafelberg, in the Division of Middelburg, and from Victoria West, and in these samples, numbered respectively 1, 2, and 3 in Table I, appended to this paper, determinations of potash and phosphorus pentoxide were made. Reference to the table will show at once that the Albany sample was very impure, and practically worthless as a fertiliser, and that from Victoria West somewhat better, though also very impure, while the Tafelberg ash was of excellent quality. In 1893 information was received that a quantity of kraal manure ash was being offered for delivery at Fraserburg Road Station, at a cost of £3 15s. per ton. A sample of this ash (No. 4) was procured and analysed, and was found to be equal in quality to the average ash afterwards obtained by Mr. Croghan in his laboratory from Cape Province kraal manures. In addition to its plant-food constituents, it contained about 13 per cent. of common salt (7.91 per cent. of chlorine) and a good deal of carbonate of soda, so that it would have had to be used with great caution on lands exhibiting a tendency towards "brack" or "alkali." It was probably with reference to lands of such a character that a farmer once wrote to the *Cape Agricultural Journal*: "Where I spread kraal manure ash only 'ganna' and 'brakbosjes' thrive."*

During 1895 a sample of raw—*i.e.*, unburnt—kraal manure (No. 5) was procured from the Victoria West Division, and, although better than that previously analysed, it still showed the defect of a large admixture of earthy material. The sample, as received in the laboratory, contained 37.42 per cent. of water.† Analysis of the ash showed that the sample was a manifest improvement on that previously examined from the same Division, though evidently capable of further purification from sand and earth.

In 1896 three more samples of kraal manure ash were examined, two of these again from the Divisions of Fraserburg and Victoria West, and the third from the Prince Albert Division. The first two (Nos. 6 and 7) showed a most excellent advance on the previous analyses, but the Prince Albert sample (No. 8) was only partially analysed, on account of the large

* *C.G.H. Agric. Journ.* (1903), **23**, 240.

† It is obviously uneconomical to transport a manure with so high a water content as this.

amount of earthy material which it contained. Nos. 6 and 7 were received in the unburnt state, and were carefully reduced to ash in the laboratory, a circumstance which accounts in part for the high proportion of fertilising constituents found in the Fraserburg sample. The amount of the undesirable chlorine, it will be seen, had been reduced to less than half that of the previous sample from that locality. No. 7, before burning, was found to yield 22.37 per cent. of ash, and only .34 per cent. of nitrogen, which shows that there would have been no advantage worth considering in transporting it any distance in the unburnt condition.

When the preliminary investigations had reached the stage above indicated, the facts elicited thereby were placed before the Fruit-Growers' Congress which met at Worcester during May, 1899, whence they passed to the Cape Horticultural Board, and, in response to resolutions passed by those bodies, steps were taken to procure specimens of kraal manure from different parts of the Colony, for the purpose of ascertaining the proportion of ash which they were capable of yielding, and of determining the manurial value of the ash. It had been generally realised that the bulkiness of the unburnt kraal manure rendered its transport by rail very costly, and it was thought that the reduction in bulk consequent on burning might, without causing excessive loss of valuable constituents,* so facilitate transport as to place the resulting ash within easy reach of localities where its use would be advantageous. Aided by the co-operation of Mr. A. G. Davison, at that time Chief Inspector of Sheep for the Colony, representative samples of kraal manure were obtained from the Divisions of Cradock, Beaufort West, Colesberg, Steynsburg, Aberdeen, Graaff-Reinet, Middelburg, Laingsburg, and Swellendam, and, in addition, samples of farm-burnt Karroo ash were obtained from Middelburg, Klipplaat (Jansenville Division), and Victoria West. These samples exhibited considerable variation in degree of desiccation and state of disintegration,† and their analysis, entrusted to Dr. J.

* When an article like kraal manure is burnt, the inorganic plant food materials—potash, lime, phosphorus pentoxide—become concentrated in the ash, and are at the same time reduced to so finely divided a condition that they are, after burning, in a state well adapted for absorption by plants. On the other hand, all the organic matter in the manure is destroyed, including the nitrogen, which is a most valuable plant food. Hence those beneficial effects which the addition of organic matter to some classes of soil confers are sacrificed by burning. There are, however, soils which already contain excessive quantities of organic matter, and are acid or "sour" in consequence. For such soils the disadvantages of adding more organic matter are obviated by reducing the manure to ash.

† Many of them were saturated with moisture, and would therefore have had to be submitted to thorough drying before being transported in bulk. Others were in large matted lumps, while others again were dry and in an excellently fine state of division. Not only the chemical composition, but also factors such as those just mentioned, influence the value of the raw article.

Lewis, was proceeded with on the following lines: The samples were all exposed to the air until air-dry, and the percentages of moisture in the air-dry samples were then determined. Portions were then burnt to ash, and the ratio of ash to the raw manure determined, after which the chemical analysis of the ash itself was proceeded with.

Mention has already been made of the fact that the manure heaps are often allowed to accumulate for many years. In the Cradock Division one such heap was sampled, first at the top (No. 9), then at a depth of four feet (No. 10), and finally six feet deep (No. 11). Table I shows the percentage results of the analyses of the chemically pure ash of each of these. The other samples collected were: Nos. 12, Beaufort West; 13, Colesberg; 14, Steynsburg; 15, Aberdeen; 16, Graaff-Reinet; 17, Middelburg; 18, Laingsburg; 19, Swellendam; 20, Middelburg; 21, Klipplaat, Jansenville; and 22, Victoria West. It is worth drawing special attention to the fact that the phosphorus pentoxide in all the above samples proved to be citrate-soluble—*i.e.*, it was in a form readily available as plant-food.

In Table I, Nos. 20 to 22, like the other analyses of this set of samples, represent the *chemically pure* ash, not the ash as obtained *in the first instance* on the farms, that ash having undergone a further combustion in the laboratory in order to yield tht results above tabulated. For the purpose of comparing the farm-ash and the laboratory-ash, the following table furnishes the full results of analyses of Nos. 20 to 22 after their *first* burning—*i.e.*, just as they arrived in the laboratory:—

No.	Water.	Organic Matter.	Potash.	Lime.	Phosphorus Pentoxide.	Chlorine.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
20	2.17	11.31	4.55	16.09	2.59	.48
21	2.78	11.02	8.10	16.42	3.11	2.62
22	1.75	11.60	10.14	18.40	2.38	1.92

If the manures represented by the above table of analyses had been burnt on the farms, the ash obtained would have been more impure, for it would in each case have contained a great deal of charred organic matter, which, while adding to the bulk of the ash, adds nothing to its fertilising value.

During the year 1900 two further specimens (Nos. 23 and 24) were examined, at the instance of the Fruit and Vine Growers' Association, Stellenbosch. Only one of these, No. 23, was a farm-burnt Karroo ash, obtained from the farm Zout Kloof, Laingsburg, and was not expected to be a fair sample, as only a small quantity of manure had been burnt, and so it would necessarily be somewhat mixed with ash derived from the wood used for starting the combustion. This would not be the case when a kiln of the manure is allowed to continue burning day and night without being supplemented by wood. No. 24 arrived in the laboratory in the unburnt condition, and was there reduced to pure ash, the raw manure containing 15.37 per cent. of water, and yielding 39.99 per cent. of ash. Of

these two samples, it is plain that the raw article from which No. 23 was derived was the purer, notwithstanding the farmer's expectations.

Towards the end of 1901 another sample of Karroo ash (No. 25) was received in the laboratory, but I am not sure of the locality whence it came. It contained 13.22 per cent. of sand.

Another kraal manure from Laingsburg (No. 26) was analysed in 1902.

For several years after this the subject of kraal manure and Karroo ash remained dormant, but in 1909 another sample of kraal manure from the Fraserburg Division (No. 27) was obtained and analysed. The manure, like some of the others above referred to, contained a considerable amount of moisture (*viz.*, 37.5 per cent.), and it was therefore first of all allowed to dry by exposure to air. The air-dried manure, which still contained 17.92 per cent. of moisture, yielded 29.05 per cent. of ash, and about 18 per cent. of the ash consisted of potash. Of course, this proportion could not be expected in the crude Karroo ash of the farm.

In 1911 three samples of kraal manure and four of Karroo ash were analysed in the laboratory, at the request of the Paarl Farmers' Association, in connection with its work as a medium of distribution for the Western Province farmers. The unburnt samples were:—

28. From Letjesbosch Siding, Fraserburg Division.
29. Very wet sample from Letjesbosch Siding.
30. From Stein's Siding, Beaufort West Division.

These samples were allowed to become air-dry, after which the percentages of moisture, ash, and plant-food constituents in each were determined, and the results given in Table I represent the manure after air-drying. No. 30 was certainly the worst of these three samples.

The four Karroo ashes analysed at the same time were as follows:—

31. A dry, well-burnt sample from Tromps Graf Siding, Victoria West Division (freshly burnt).
32. A dry, well-burnt sample from an old heap of ash on the same farm as No. 31.
33. A well-burnt ash from Stein's Siding, Beaufort West Division.
34. From Letjesbosch Siding, Fraserburg Division.

No. 34 contained no less than 23.36 per cent. of pebbles over 1 mm. in size, together with orange peel, acorns, oak leaves, and feathers, but had apparently, before receiving all those admixtures, been a well-burnt ash. On account of the quantity of small stones in this sample, the percentages of plant food after removal of the pebbles were calculated, and worked out as follows:—

Potash	9.55	per cent.
Lime	19.04	„
Phosphorus pentoxide	2.72	„

Towards the close of 1911 the Civil Commissioners of the Divisions of Victoria West, Laingsburg, Cathcart, Kingwilliamstown, Humansdorp, and Malmesbury were each requested by circular to obtain for analysis from some reliable farmer in their respective Divisions 25 lb. samples of kraal manure, and also, in districts where it was customary to convert the manure into ash, 10 lb. samples of such ash, care being taken, in the collection of each sample, that it represented the bulk, and not merely the surface of the kraal or heap. As a result of this circular two samples of Karroo ash and seven of unburnt manure were received in the Government Laboratory. The seven samples of manure were as follows:—

35. From Ganze Kraal, Victoria West Division. A very old and lumpy sample.
36. From Rietvlei, Klein Zwartberg, Laingsburg Division. A good sample.
37. From The Towers, Darling, Malmesbury Division. Sample mixed with stones and rubbish.
38. Another sample from The Towers. Apparently very old, containing a large amount of stones and straw.
39. From Zeekoe River, Humansdorp Division. Sample contained a fair amount of soil.
40. From an old kraal belonging to a native in the Isinyoka Valley, Kingwilliamstown Division. A very poor sample, stated to be more than ten years old, and apparently more a soil than a manure.
41. A good sample from Winston, Cathcart Division.

Only potash determinations were made in these manures, the results of which are arranged in Table II. Nos. 37 and 38 contained respectively 28.2 and 21.5 per cent. of stones larger than 1 mm. diameter. These two fertilisers were therefore sifted prior to determining the potash which they contained. The percentages of potash in the *sifted* samples were:—

No 37	1.64
No. 38	2.76

On the whole, judging from their physical appearance, this last set of samples cannot fairly be regarded as representative, and the determinations made would therefore afford only a vague idea of the general composition of kraal manures, hence the fuller investigation that had been hoped for still awaits performance.

The two samples of Karroo ash received, together with the last lot of kraal manures, were:—

42. A well-burnt grey ash from Winston, Cathcart Division.
43. A good sample of ash, with little sand, from Ganze Kraal, Victoria West Division.

In these, too, only potash was determined.

TABLE I.

Analyses of Karroo Ash.*

* Black type indicates farm-burnt samples; ordinary type indicates samples burnt in the laboratory.

No.	Potash.	Lime.	Phosphorus pentoxide.			Chlorine.
			Water soluble.	Citrate soluble.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	**.54**		**1.35**		**1.89**	
2	**13.70**		**.37**		**4.80**	
3	**2.30**				**2.17**	
4	**11.96**	**10.19**			**1.45**	**7.91**
5	5.18				2.84	
6	19.27	34.30			4.74	3.45
7	15.09	26.94			2.04	
8					**1.17**	**.59**
9	7.65	20.77		2.25	2.25	2.48
10	15.27	25.93		2.50	2.50	8.03
11	14.92	24.85		3.07	3.07	6.37
12	6.54	14.29		1.74	1.74	3.41
13	3.79	10.18		3.07	3.07	.35
14	3.25	8.67		2.27	2.27	.28
15	8.86	31.08		4.65	4.65	7.46
16	5.71	19.69		2.30	2.30	4.26
17	7.08	34.90		5.66	5.66	1.21
18	7.23	14.15		6.76	6.76	3.20
19	3.40	10.46		.86	.86	.64
20	**5.26**	**18.62**		**3.00**	**3.00**	**.56**
21	**9.39**	**19.05**		**3.61**	**3.61**	**2.80**
22	**11.43**	**20.76**		**2.68**	**2.68**	**2.24**
23	**12.02**	**36.99**			**2.00**	**12.02**
24	7.00	19.50			.20	
25	**11.41**	**33.83**		**1.30**	**2.48**	**13.44**
26	**12.07**	**36.54**		**1.67**	**1.84**	
27	18.04	32.43	1.75	2.93	2.93	
28	10.43	24.55		2.83	2.83	
29	10.66	21.52		3.07	3.07	
30	7.55	16.09		3.57	3.57	
31	**12.48**	**19.40**		**3.31**	**3.31**	
32	**9.04**	**15.66**		**2.97**	**2.97**	
33	**11.44**	**15.56**		**3.05**	**3.05**	
34	**7.32**	**14.59**		**2.08**	**2.08**	
42	**4.01**	**4.99**				
43	**9.33**	**22.67**				

Excluding the seven samples whose analyses were less complete than the others, namely, Nos. 1, 2, 3, 5, 8, 42, and 43, the results obtained from the remaining 29 Karroo ashes may be summarised in the same way as the analyses of Mr. Croghan were earlier in this paper—

	Potash.	Lime.	Phosphorus Pentoxide.
	Per cent.	Per cent.	Per cent.
Maximum	19.27	36.99	6.76
Minimum	3.25	8.67	.20
Average	9.85	21.81	2.86

It must be admitted that there are great differences between these maxima and minima, but, however incomplete the whole investigation may be, it must also be admitted that, taken all in all, the average Karroo ash is an article that deserves a far more widespread employment than it receives. Large quantities of it are lying practically waste in the Karroo, and, by reason of its rich potash and lime content, it is just the manure, as Mr. Croghan rightly said, to be used by way of supplement to the guano from the Government islands, which, in its turn, supplies the nitrogen that is lacking in the Karroo ash.

In order to make this record as complete as possible, the following table is appended, showing the composition, in their unburnt state, of those kraal manures which were burnt not on the farms, but in the laboratory:—

TABLE II.

No.	Water.	Organic Matter.	Nitrogen.	Ash.	Potash.	Lime.	Phosphorus Pent-oxide.	Chlor-ine.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
5	37.42	34.04	.28	28.54	1.48		.81	
7			.34	22.37	3.38	6.03	.46	
9	19.44	36.59	1.40	44.97	3.44	9.34	1.01	1.11
10	12.87	57.86	1.26	29.27	4.47	7.49	.73	2.35
11	14.17	54.60	1.05	31.23	4.66	7.76	.96	1.99
12	9.56	35.29	1.62	55.15	3.61	7.88	.96	1.88
13	9.93	41.43	.98	49.64	1.88	5.05	1.48	.17
14	8.45	32.14	1.47	59.41	1.93	5.15	1.35	.16
15	16.39	54.81	1.19	28.80	2.53	8.95	1.34	2.14
16	14.30	47.16	1.54	38.54	2.20	7.59	.89	1.64
17	10.64	56.92	1.68	32.44	1.59	7.83	1.25	.45
18	12.83	33.80	1.12	53.37	3.86	7.55	3.61	1.71
19	20.10	48.64	1.12	31.26	1.06	3.27	.27	.14
24	15.37	44.64	1.88	39.99	2.80	7.80	.08	1.38
27	17.92	53.03	1.45	29.05	5.24	9.42	.85	
28	12.33	38.89	1.44	48.78	5.09	11.98	1.38	
29	12.09	34.80	1.54	53.11	5.66	11.43	1.63	
30	10.81	61.78	1.58	27.41	2.07	4.41	1.05	
35					4.58	7.75		
36					3.52	5.93		
37					1.64	1.91		
38					2.76	2.75		
39					2.01	2.06		
40					.87	1.92		
41					3.14	2.73		

TRANSACTIONS OF SOCIETIES.

Royal Society of South Africa.—Wednesday, May 19th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*The equivalent mass of a spring vibrating longitudinally*": Prof. A. **Brown.** The paper dealt with the allowance to be made for the mass of a spring when a weight attached to it is oscillating under gravity and the tension of the spring. Experiments were described confirming the theoretical results.—"*The occurrence of Dinosaur Bones in Bushmanland*": Dr. A. W. **Rogers.** Dinosaur bones were found in a well in Bushmanland at 112 feet below the surface. The well is in an old valley cut in gneiss and filled in with local debris. Probably the climate became dry while the dinosaurs lived there, and since then the valley has been steadily filled up. "*Description of the Dinosaur bones from Bushmanland*": S. H. **Haughton.** The bones discovered by Dr. Rogers consist of a maxillary tooth and portions of the hind limbs and caudal vertebra of a medium-sized Ornithopodous Dinosaur. They were described by the author under the name *Kangnasaurus Coetzeei.* The form is younger than *Camptosaurus,* but no estimate of its exact age could be given.—"*The Coccidæ of South Africa*": C. K. **Brain.** The paper, which is the first contribution to a catalogue of the Coccidæ of South Africa, dealt with five sub-families, *viz*: —*Pseudococcinæ, Orthesiinæ, Coccinæ, Monophlebinæ,* and *Margarodinæ.* Sixty-three species and two varieties were described, thirty-two for the first time. "*A Note on the molecules of liquid crystals*": J. S. **van der Lingen.** The object of the paper was to show the effect of bi-prisms on the Lane spots. Experiments carried out with prisms of sodium chloride show that the spots are "fluted," and that the central spot is elliptic instead of circular.—"*On the 'lines' within Röntgen interference photographs*": J. S. **van der Lingen.** These lines are due to the ruptured surface, which will most probably resemble an echelon grating. Sodium chloride, quartz, silicon, and magnesium hydroxide photographs were described. These show "irregular spots" under certain conditions.

Wednesday, June 16th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Osteology of Palæornis with other notes on the genus*": R. W. **Shufeldt.** A description was given of one of the most abundant parrots of India—*Palæornis torquatus,* or the ring-parrot—so named for the reason that in the adult a ring or collar forms part of the plumage of the neck. These birds are supposed to have been known to the Greeks and Romans, but they were not considered as a sub-family of parrots until 1825.—"*Note on apparent apogamy in* Pterygodium Newdigatæ": Miss A. V. **Duthie.** A cleistogamous variety of the South African orchid *Pterygodium Newdigatæ,* of special interest because cleistogamy, rare enough among orchids, appears here to be accompanied by apogamy. Sections of the ovary and column at various stages of development show no trace of pollen tubes. The gland-like "pollen masses" do not appear to develop beyond the mother cell stage.—"*A Record of plants collected in Southern Rhodesia*": F. **Eyles.** This record includes representatives of 160 families, 869 genera, and 2,397 species, besides 112 varieties.

Wednesday, July 21st: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*A new Type of Fossil Reptile from the Karroo.*" S. H. **Haughton**. A somewhat incomplete skull, with associated limb-bones and vertebræ, from the upper *Tapinocephalus* zone of the Beaufort West District were exhibited. In general form it recalls the Dinocephalia, although much smaller; but in the possession of a few small palate teeth, in the vertical occipital plate, the shallowness of the basicranium and some other features it recalls the Gorgonopsia.—"*Note on Conus shells illustrating variation in markings*": K. H. **Barnard.** A series of shells was exhibited, showing gradation in the pigment from a condition in which the coloration is strongly marked to that in which the shells are practically colourless. The question of the origin of the pigment and its relation to the environment and heredity of the mollusc was discussed.—(1) "*Simple apparatus for finding* g"; (2) "*Simple apparatus for standardising a*

given Vibrator": J. S. **van der Lingen.** The apparatus described does not involve assumptions of dynamical quantities that the student cannot determine for himself, and is adapted to give him some definite idea about the acceleration of a freely falling body. Apparatus was also described by which velocities and accelerations may be determined without assuming the time of vibration of some vibrator.—"*Note on Astronomical Photometry.*" Dr. J. K. E. **Halm.** An account was given of a method which claims to derive from the measured diameters of the star discs on a photographic plate the brightness or "Magnitude" of any star on a self-consistent basis. The results obtained for the stars of the Cape Astrographic Zones demonstrate a perfect agreement of the Cape system with the Harvard photographic system. Comparisons between the photographic and visual magnitudes lead to the conclusion that the "colour" of the stars is a function of their brightness, faint starts being slightly redder than bright stars. This fact is tentatively attributed to the existence of absorbing matter in space. It is also found that, on the average, stars are actinically brighter in the Milky Way than in other regions.—"*The Electromotive Changes accompanying activity in the mammalian Ureter*": Prof. W. A. **Jolly.** The neuro-muscular duct leading from the kidney to the urinary bladder was removed from a recently killed rabbit. A glass canula was inserted into the ureter at each end. It was then placed in a moist chamber, kept at body temperature. When warm salt solution is passed at low pressure through the ureter from the upper end, waves of muscular contraction pass over it. Connection with the string galvanometer was made and the deflection of the instrument caused by each wave of activity recorded photographically. The curve resembled in all essentials that obtained from the beating heart.—"*A new Aloe from Swaziland*": I. B. **Pole-Evans.** A new species of Aloe, found in Swaziland by Mr. R. A. Davis, was described and named *Aloe suprafoliata.* It has rigid, somewhat fleshy distichous leaves. The flower spike is slender, unbranched, and bears rather loosely-attached rose doree flowers.

Wednesday, August 18th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*The Growth Forms of Natal Plants*": Prof. J. W. **Bews.** The author gave a detailed description of his work on the growth forms of Natal plants.—"*The South African Rust Fungi* (1) *The Species of Puccinia on Compositæ*": I. B. **Pole-Evans.** Descriptions were given of the species of Puccinia based mainly upon material which the author and his colleagues had collected during the past ten years in South Africa, and which is now represented in the Mycological Herbarium at Pretoria. The object of the collection was mainly to elucidate the life-histories of various rusts destructive to economic crops.—"*Heating and Cooling Apparatus for Röntgen Crystallographic Work*": J. S. **van der Lingen.** The apparatus described was devised by the author to facilitate the work of those who wish to carry on research on the determination of the energy of an atom at zero temperature and at very high temperatures.

NEW BOOKS.

Lewin, E.—"*The Germans and Africa: their aims on the Dark Continent and how they acquired their African Colonies.*" pp. xviii, 317. Map. London: Cassell & Co. 1915. 10s. 6d. nett.

Hartill, Marie.—"*Elementary course of South African History to 1820.*" 12mo. Maps and illus. pp. xiv, 182. Capetown: T. Maskew Miller. 1914.

Stoneman, Dr. Bertha.—"*Plants and their ways in South Africa.*" Crown 8vo. pp. xii, 387. New ed. revised and enlarged. London: Longmans, Green & Co., 1915. 5s.

SOUTH AFRICAN AGRICULTURE: AN ANALYSIS.

By P. J. du Toit.

In considering the agricultural condition of a country one has naturally to take account, among other factors, of the people first of all. A correct appreciation of the characteristics of an old, a settled people, of one nationality, is, perhaps, not difficult to acquire; indeed, it would be intuitive. But, in circumstances such as ours, we are concerned not only with the characteristics of men of mainly three European nationalities—Dutch, French, and English (in the order of their advent)—or the descendants of those men, but also with the effect each of these has had upon the other, with other changes produced by environment, with the effect brought about by contact with native races, and with the results that followed on great political changes. So we have a complex problem in the main factor which I have referred to. First came settlers from Holland, who gradually spread out over the districts in the neighbourhood of Table Bay, built comfortable homesteads, planted trees, beautified the land they occupied, and provided from the soil what was necessary for their own existence and comfort, for the requirements of the East India Company, and for the ships that called at the Bay. In the earlier part of this period, which extended over one hundred and fifty years, came the Huguenots, who brought with them a good knowledge of grain-growing, viticulture and horticulture, settled among the Dutch Colonists, intermarried with them in course of time, and blended, or rather mixed, in various degrees, attributes of men who had sprung from two different races. Lastly, we have the advent of the English, extending over more than a hundred years, both as agriculturists and in other vocations, but chiefly the latter. The last-mentioned section of the European community has not, so far, intermarried with the two earlier sections to a great extent, or *vice versa*; so, for our purpose, we may accept the usual division of the European population into two sections. So far as agriculture is concerned, one appears to be distinguished, as a whole, by caution, love of freedom, endurance and tenacity; and the other by enterprise, activity and self-reliance. It seems a matter for congratulation that we have these varying qualities constantly acting and reacting upon one another, though doubtless, if they were fused, the advantage to the country would be the greater. On the whole, we have a farming community whom adversity or discomfort does not daunt, and is firmly attached to the soil; and in this we probably have the reason for the peopling of the most arid parts of the country—I refer to the far Western districts—and the rearing of flocks and herds there under conditions of isolation, uncertainty, and disappointment that would drive a less tenacious people into the towns.

Here was a vast country in the hands of, at first, a few white inhabitants, men who had sprung from a sea-faring, courageous, freedom-loving people—a people who extended

commerce to many parts of the globe, and were imbued with a colonising spirit. I refer, of course, to the Dutch of the seventeenth and eighteenth centuries. And not only was this new country vast, but it was also a fair, a most attractive land. All who know what is now called the South-Western districts could easily realise how great must have been the call of the magnificent mountain ranges, the well-watered valleys, the immense stretches of cultivable land, the certain and adequate rainfall and the glorious climate, to the early settlers and their descendants and to the Huguenot refugees—men with the spirit of pioneering, the instinct of freedom, and the courage of independence. To so small a population the land was limitless, and distance from the only market necessitated that they should be, as far as possible, independent for their livelihood of the town population; and so, to a large extent, they became their own blacksmiths, their own carpenters, their own builders, their own harnessmakers, their own farriers, their own bootmakers, their own handymen. Occupation of the land extended inland, and gradually spread to distant parts of the Cape. When, in the beginning of the nineteenth century, the Cape of Good Hope was definitely annexed by England, and a new rule was imposed on the country, there was a human product in this land such as I have tried to sketch—one that loved to be free, and did not fear to rely upon its own right hand, its own strength of character, and its own resourcefulness. This human product, no longer wholly Dutch or French, but doubtless in the space of a century and a half changed by its environment, though still retaining largely the characteristics of its ancestors, chafed under the new rule; and, thirty years after British occupation, the Great Trek commenced—an undertaking which the environment of this older section of the people made possible. In course of time this country, now the Union of South Africa, with an area of, roughly, 477,000 square miles, became occupied from end to end by a very small European population, the rural section being owners of large farms, removed from the advantages of good education and of easy intercourse, and having a limited market for their produce and their live-stock. Here, then, was produced in the main, in the course of two centuries, a situation the exact reverse of what was required for the advancement of agriculture: instead of small holdings intensively cultivated were large farms hardly cultivated at all, and used chiefly for the rearing of herds of cattle and flocks of sheep; instead of proximity to large markets, rapid transport, much intercourse and good education, were distant markets, slow wagon transport, infrequent association, and scarcely any education. So we are impelled to the conclusion that, while the qualities required for progress in agriculture were always and are possessed by the South African farmer, political and other considerations dispersed his activities over so great an area that for generations production languished.

It was inevitable, moreover, that native wars, and different aspirations of the white races, should absorb a vast amount of

attention until contentment and a common feeling of unity had been produced, and that agriculture should be thrown into the crucible.

Now, let us consider for a moment the effect which the contact of the European population with the native races has had on the farmer. On the European was laid the task, for his own protection, as well as on higher grounds, of civilising the barbarian. The latter gained, but it was inevitable that the former should lose. In the sphere of labour the native exerted a marked influence on his European master, to the latter's detriment. The native, in the course of time, became the worker, and is to-day the worker, physically, mentally, and morally improving himself at the European's physical, mental, and moral expense, producing an unfortunate class whom we know as "poor whites." But the native's labour is not efficient; and who shall estimate the retardation from this cause alone?

If we take a rainfall map, we find that, generally speaking, and excluding the coastal belt on the West and South Coasts, the rainfall increases as one goes east or north: that is, the rainfall is lowest in the West, and increases as one goes east; lower in the South, and increases as one goes north. Again, excluding the West and South coastal belts, the soil is richer in the West than in the East, in the South than in the North. The population is distributed less, however, according to richness of soil than according to rainfall, especially regularity of rainfall, which determines the productivity of the soil and the ability of the soil to sustain population. But, unfortunately, nearly the whole of the country, so far as rainfall is concerned, is dependent upon a summer precipitation, somewhat irregular and uncertain, and over a huge area deficient as well. Rainfall must, to a great extent, dictate agricultural policy and methods. At the same time, there is a modifying element in the soil, in that richness, where it can be turned to account by irrigation, will counterbalance the effects of a small or an irregular rainfall; and there is also this further modifying element, that the smaller the rainfall, the greater the freedom from stock diseases. However, under very varying conditions of soil and climate we have developed a variety of agricultural activities which it would probably not be incorrect to call unique, and which presage a hopeful future.

Coming now to circumstances as they obtain to-day, we have a small rural population scattered over a vast area—a population possessing attributes inherited from virile, industrious, frugal, tenacious, enterprising stocks, moulded by physical and political conditions into a hardy, well-developed, assertive people, and inevitably being fused into an indivisible nation; but, unfortunately (speaking from an agricultural point of view), labouring under the disabilities imposed by distance, by uncertain climatic circumstances, and by constant contact with an inferior race. Consider the length of railway lines and of roads that had, and still have, to be constructed, the cost and upkeep of these, the number and cost of bridges, the consequent cost of transport,

and the expenditure of time in disposing of products or purchasing supplies; the cost of building and of education; the dearth of opportunity; the tendency to become self-centred, and, therefore, the distrust of advice and teaching. Is it a matter for surprise that our agricultural advancement has been slow? For two and a half centuries the tendency of the agricultural population was centrifugal. We have only begun to realise that it is our duty, our necessity, to become centripetal. We have reached the turning in the lane.

I must now introduce more specific details and touch upon various agricultural industries which we have established, indicating how the views I have ventured to advance seem to be borne out by statistics.

Of our agricultural and pastoral industries, the breeding of wooled sheep is the oldest and the most important. Wooled sheep were first introduced by the Dutch East India Company in 1654, or two years after the occupation by that Company of the Cape of Good Hope.

In 1689 the next importation took place, also by the Company, but this time from Spain. In 1790, Colonel Gordon, an officer in the Company's service, introduced a number of fine merino sheep of the Escurial breed. Other importations took place at about this time, since when the breeding of sheep for their wool began to be regarded seriously. The next introductions were made by the British settlers of 1820, being sheep of the English breeds. Subsequent purchases were made in Saxony, and, still later, in France.

Latterly, fairly large importations have taken place, principally from Australia.

We exported from the Cape of Good Hope in

1714	650	lb. of wool.
1835	215,868	,, ,,
1855	12,016,415	,, ,,
1875	40,339,674	,, ,,
1895	65,632,613	,, ,,
1909 (the last year before Union)	101,007,893	,, ,,

Similar comparative figures for the other Provinces are not available, but note, from the exportations in the following years, the stagnation from 1890 to 1899, due probably to crippled earnings of farmers on account of locusts, disease, and drought:

1885	34,432,562	lb.
1890	65,655,917	,,
1895	65,632,613	,,
1899	69,289,606	,,

On the other hand, note the progress in the Union since 1905:

1905	77,187,226	lb.
1909	130,981,518	,,
1911	132,207,029	,,
1913	176,971,865	,,

Another pastoral industry, the breeding of cattle, and its concomitant, the output of dairy produce, bids fair to become important. One hundred and forty years after the occupation of the Cape of Good Hope by the Dutch East India Company the first introduction from oversea seems to have taken place, for crossing with native cattle. It was a century later before the importance of dairying began to be advocated. In the absence of the railroad, the Africander ox was depended upon for the transport of all supplies and all products. There being at the time practically no market for butter, there was little inducement for the improvement of the herds. Serious attention to the manufacture of high-class butter, and therefore to the improvement of the milk-producing capacity of our cows, commenced twenty years ago only. Now we seem to be on the eve of adding meat and butter to our list of exports.

The ostrich feather industry, at present going through a period of severe depression, but, I believe, destined to become again one of our chief sources of income, has had a chequered, though interesting, history. Started in 1865, it was booming in the late seventies and early eighties, nearly extinguished in the later eighties, and revived in the later nineties; again, since eighteen months ago, it is in the depths of depression. The export figures form interesting reading:—

	lb.	Valued at £	Per lb. £	s.	d.
1870	28,786	91,229	3	3	0
1875	49,569	304,933	6	3	0
1880	163,065	883,632	5	8	0
1885	251,984	585,270	2	6	0
1890	212,276	517,009	2	8	0
1895	353,626	527,742	1	10	0
1900	412,832	879,751	2	2	0
1905	471,024	1,081,187	2	5	0
1910	741,078	2,272,846	3	1	0
1913	1,023,307	2,953,587	2	18	0

Note here also the rapid progress since 1905. Although the average value per lb. was in 1913, the last year of prosperity, only half as much as in 1880, when the previous boom occurred, such great improvement in breeding and feeding had taken place in the last twenty years or so that the industry prospered at the lower realisation, and the ostrich farmer was the envy of other agriculturists.

The first attempt to introduce the Angora goat into South Africa is said to have been made in 1825. Thirty rams and ewes were imported in 1856, and subsequent shipments arrived in 1857, 1867, 1879, and 1880. So much intelligent care was bestowed on, and so much industry applied to the breeding of Angoras that in 1891 there were 3,184,018 in this country, and some individual goats were superior to any which Turkey produced The shipments of mohair were:—

	lb.	Value.
1857	870	£10
1867	43,348	£4,985
1877	1,429,045	£116,382
1887	8,756,116	£268,446
1897	12,055,390	£676,644
1907	19,125,425	£914,597
1913	18,523,197	£876,255

The stagnation observed with regard to the production of wool in the nineties is equally apparent in the case of mohair during the same years.

The exports were:—

1891	10,183,752 lb.
1895	10,354,870 lb.
1899	12,844,454 lb.
1901	10,615,948 lb.

In 1865, when our exportation amounted to 9,609 lbs., Turkey exported to the United Kingdom 2,421,188 lbs. By 1887 we exported to the United Kingdom more than Turkey did—8,756,116 lbs., as against 6,714,816 lbs.—and since then the Turkish export only twice exceeded our own—in 1895 and 1898. Since 1907 we have been sending to the United Kingdom nearly twice as much as Turkey, and we have maintained this lead, though average Turkish mohair still commands about 2d. to 3d. per lb. more than ours. We do not find in mohair the exceptional advance in the last decade which obtained in regard to the other pastoral industries I have mentioned; but mohair is an article for which there is a limited demand, and the stimulus to production, after the Anglo-Boer War, in the case of wool, dairy produce, and ostrich feathers became quiescent so soon as we reached the limit of successful competition with Turkey for the world's consumption of about 30,000,000 lbs. per annum, of which we produce more than half.

Maize we always produced in sufficient quantity for local consumption, but when trial shipments indicated that there was a profitable market oversea, production increased. We exported in:—

1907	464,041 muids.
1908	464,485 ,,
1909	1,551,187 ,,
1910	1,760,208 ,,

Then years of drought set in, and exportation gradually dropped to 234,676 muids in 1913, while in 1914 it again rose to 1,156,247 muids.

Our production in 1904 was 3,611,588 muids, and according to the last census it was 8,632,516 muids in 1910; and this year it is reliably estimated at over 10,000,000 muids.

In 1891 the Cape of Good Hope produced 909,163 muids of wheat and 603,377 muids of oats. (Statistics are not available

for a comparative statement as regards other parts of the Union.) In the succeeding years of the last century:—

	Wheat. (Muids.)	Oats. (Muids.)
1892	1,296,966	545,706
1893	1,032,543	463,488
1894	821,564	325,782
1895	729,216	551,501
1896	689,679	293,881
1897	650,277	482,451
1898	740,249	603,537
1899	Not available.	

After the Anglo-Boer War the production for the Union was:—

	Wheat. (Muids.)	Oats. (Muids.)
1904	708,695	871,413
1908	1,150,000	1,750,000
1911	1,810,315	2,060,922

Again we observe the increase in production in recent years.

Viticulture in South Africa is, on the whole, unfortunately, a stationary industry. If the restrictive policy now in force were maintained—and, so far as one can judge, there is no present indication that it is likely to be altered to the advantage of that industry—artificial means of creating an export trade will alone induce greater production.

Under present conditions, the most that can be hoped for is increase in production in proportion, more or less, to increase of population exclusive of the Native races. For the purpose of the conclusion which I propose to point to, further remarks on the subject of viticulture are unnecessary.

As regards tobacco growing, the only figures which register the position of the industry in the Union, as a whole, are those for the census years 1904 and 1911, when the production was 12,112,565 lbs. and 14,961,199 lbs. respectively. After 1911 the production increased still more, but latterly drought, and probably also manipulation of the market, caused a temporary setback. It may be that, so far as internal consumption is concerned, production will increase slowly, if at all. The immediate future prosperity of this industry lies in so improving the quality that an export market can be developed.

Fruit, being a perishable article, is in a different category to any of the branches of agriculture already mentioned. Our ripening seasons being the reverse of those in the Northern Hemisphere, where the largest markets exist, we are in a favourable position for an export trade, and, therefore, production is regulated to a great extent by the quantities which these markets

can consume. While the census returns of production are so presented that a comparative statement cannot be given, it is generally known that exportation of fruit gave a great impetus to the growing of fruit. We have in fruit culture, as in maize-growing, a clear proof that the agriculturist, like every other class of the community, will invest when he sees the opportunity of doing so profitably; he cannot be expected to produce until he can sell: market first, production next.

The sugar industry dates back to 1849. Labour difficulties, among others, beset the venture. Even after these were overcome by the importation of indentured Indian labour, begun in 1860, the market for Natal sugar was very small. "A welcome impetus was given to the industry," says David Don, "by the discovery of diamonds in Griqualand West," as a result of which four times the number of vacuum pans were installed. Better transport facilities raised the production to 19,369 tons in 1894. During the next few years the production was almost stationary, though it advanced somewhat after Natal entered the Customs Union with the Cape and the Free State in 1899. Soil, labour, and every requirement for production were there, but Natal sugar still groped for a wide market. It was the Customs Convention of 1906 that gave Natal sugar a free market all over British South Africa, and suitable protection at all the seaports. We see the results in the following tables:—

Exports from Natal to other parts of South Africa.

	1906.	1907.	1908.	1909.
Tons...	25,001	26,226	38,439	48,570

Since 1910 trade as between Provinces is not recorded.

Oversea Imports into British South Africa

	1906.	1907.	1908.	1909.	
Tons...	56,411	53,233	45,743	33,661	
	1910.	1911.	1912.	1913.	1914.
Tons	29,676	36,482	19,385	29,227	23,576

That is, as we facilitated trade locally, so importation decreased.

Now note the increase in production:—

	1906.	1907.	1908.	1909.	1910	1911.	1912.
Tons	31,190	35,100	51,200	77,491	84,437	92,000	96,000

About fifty-one years ago black-wattle seed is said to have been planted for the first time in Natal, where the economic value of wattle bark was recognised by the late Sir George Sutton twenty years later. In 1887 the first shipment of bark oversea was made, and in 1903 exportation reached 13,591 tons. It is interesting to observe that as production increased prices declined. We produced in

1904	15,818 tons.
1905	17,512 ,,
1906	16,607 ,,
1907	27,239 ,,
1908	27,830 ,,

and thereafter rapidly increased the output until it reached in

1913 .. .. 72,858 tons;

but the prices realised in England fell from £8 11s. 5d. per ton in 1904 to £7 5s. 1d. per ton in 1908, and £6 9s. 5d. per ton in 1913; and now we have reached a point at which marketing in another form has to be resorted to in order to find a wider demand and so create stability or, we hope, greater prosperity for this industry, namely, by exporting the bark extract in place of the bark itself.

If we analyse the statistics quoted, two outstanding facts are observable. Firstly, there was a period of stagnation as regards the production of wool and mohair in the last decade of the previous century, attributable, in my judgment, as I have already mentioned, to diminished earning power of farmers on account of disease among stock, periods of drought, and visitations of locusts, the destruction of which by arsenical poisoning was not then known. Secondly, a period of unparalleled progress commenced in about 1905 to 1908, due to several favourable causes operating simultaneously. In examining these causes, the various products dealt with above fall into three groups:—

I. *Wool and Ostrich Feathers.*—Much greater knowledge in breeding, management and marketing had been acquired.

II. *Ostrich Feathers, Maize, Fruit, and Wattle Bark.*—Oversea markets had either been created or had extended.

III. *Butter, Wheat, and Sugar.*—A free internal market had been established over the whole of British South Africa by a Customs Union, and encouraging railway rates had been fixed.

The lesson in regard to all three groups, and therefore in regard to all our chief agricultural and pastoral products, is that there is no educating factor as powerful as the creation of wealth. There are several direct agencies to be employed for this purpose, though some are more potent than others. Our needs lie in a number of directions, all of which will, when applied, place agriculture in the position, not of the chief industry, for that it is already, but in a far better position than it holds to-day: railways to reduce distance; suitable railway rates; better roads and bridges; better management of markets; more education, agricultural and general, and therefore a better opportunity to understand the needs of plants and animals, and to assimilate technical information; more irrigation, and better use of water; above all, more business in agriculture, and wider markets. But when this is said, what does it really amount to? At the bottom of all our difficulties is distance, and always distance, and, surely, the only ultimate means of reducing distance is population. We must look to population as the first essential in the advancement of agriculture: population to consume our products, population to supply the farmers' wants, population to make railway and road extension economically advisable; in short, population to

create wealth, to make the return from the soil the greater, both to the individual farmer and to the people as a whole.

It is the politician's sphere to say how that population is to be obtained. I may be permitted to say, however, that rural population follows on urban; that greater market must precede increased production. The farmer will produce according to the market he has. He will not produce more, because, obviously, he cannot be expected to produce at a loss, or even at a less profit than that which he may consider a fair return for his labour and his expenditure. Where, then, is this market to be? Our oversea market, valuable as it is, is necessarily one in which the products of several countries compete; it is one in which distance, freight, railway rates, etc., are weighty factors; it is also one outside the control of ourselves; it is one influenced by the vicissitudes of climate and also of politics. It is, therefore, to some extent an uncertain market. Is it not better to have a market in which distance and freight are eliminated, which is within our own control, which, when influenced by climatic conditions, yet gives us the benefits as well as the disadvantages of such conditions; which, lastly, when influenced by politics, yet gives us a voice therein? The closer an export market, capable of absorbing our products, is to our gates, the more would be the benefit we might expect to derive from it. South Africa, however, is thousands of miles from any large market. Our geographical situation demands a large internal market.

The greatest advancement in agriculture took place after the Anglo-Boer War. Firstly, we entered upon more settled political conditions. For many years previously political considerations overshadowed the agricultural. Secondly, there was considerable expansion of the gold industry, and consequent increase in the consuming population. Thirdly, the producer was brought nearer the market by extensive railway construction, the mileage open being 4,534 in 1903 and 8,281 in 1913, an increase of nearly 55 per cent. in ten years.

Agricultural industries depend upon others, and other industries upon agricultural. The two form a circular movement. I have endeavoured to indicate what is required to enlarge the circle. Let me express it in this formula: industries, population, internal markets. I have attempted to show that our population, urban and rural, have inherited qualities that should hearten us for the future, but that certain easily recognisable causes have held back agricultural development in the past. What boots it that we have the material if we do not supply the means for employing that material to advantage? What value have rich soil and favourable climate if they are not turned to full use? We may devise ways of preventing erosion of the soil, preach conservation of water, encourage irrigation, demonstrate thorough tillage, facilitate importation of pedigree farm stock, protect our animal industries, afford all the educa-

tion we can, but human capacity will set a limit to agricultural progress; a large edifice cannot be built from a few bricks; a great agricultural industry cannot be raised by a small population. Let us apply the right formula, and our agriculturists will not be found wanting.

Oil Producing Plants from South Africa.

The International Institute of Agriculture publishes, in its *Monthly Bulletin of Agricultural Intelligence** a brief summary of a chemical examination, by Sprinkmeyer and Diedrichs, of the Manketti fruit (*Ricinodendron rautannemii* Schinz), plentiful in the Okawango district (South-West African Protectorate). This fruit furnishes a very quick-drying oil, which certainly has an industrial value, and may possibly also be used as a farm-food. The fruit is aromatic, and its mesocarp, which constitutes 30.6 per cent. of the fruit, contains 31 per cent. of saccharose. The authors record the following analytical results:—

	Mesocarp.	Oil seeds (decorticated).
Water	10.70	4.70
Ether extract	.99	59.40
Albuminoids	6.83	26.95
Ash	4.60	3.02
Crude fibre and nitrogen-free extract	76.88	5.93

From the extracted oil the following constants were obtained:—

Specific gravity (15° C.)	.9306
Iodine value	128.55
Saponification value	193.31
Reichert-Meissl value	.75
Ester value	192.3
Acid value	.70
Optical behaviour	inactive.

Another oil-producing plant that may possibly be found of economic value is *Madia sativa* Mol., an annual closely allied to the sunflower. This plant was experimentally grown last year in the National Botanic Gardens, Kirstenbosch, and Professor Pearson sent some of the seed produced to the Director of the Imperial Institute for examination. These seeds yielded a yellowish-brown liquid oil, equivalent to 38.4 per cent. from the dry seeds.† This oil is of the semi-drying class, and thus unsuitable for making paint, but it may prove useful as an edible oil, and could also be used for burning and in the manufacture of cheap soap. The meal left after extracting the oil shows more proteins than either sunflower or undecorticated cotton-seed cake, and might prove of value for cattle-feeding.

* (1915), **6** [5], 703-705.

† *Bull. Imp. Inst.* (1915), **13**, [3], pp. 344-346.

SECULAR CHANGE IN THE PERIOD OF U CARINÆ.

By Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E.

It has been known for well-nigh a century that the period of some variable stars exhibits secular change of a very definite character. Thus, in 1853, Argelander found that the period of β Lyræ had been increasing during the years that it had been under examination.

The secular variation of a number of other stars has also been determined by workers in this field of astronomical research.

In the Southern Hemisphere continuous observations carried on at Lovedale for twenty-five year have revealed this fact: that the majority of short-period variable stars—that is, stars whose period amounts to a few days, and whose variation is in some as yet unknown way intimately related to binary movement—is subject to a secular change in period.

In certain cases this secular change seems to be that of regular acceleration or regular decrease; change, no doubt, exceedingly minute, but yet appreciable in the lapse of years. Thus, if we imagine a star whose period is completed in five days increasing only

0.000001 day,

every revolution, that is, one-tenth of a second, it would seem, at first sight, that such a change would, with difficulty, be detected. But when we deal with observations extending over a quarter of a century, the accumulated acceleration becomes appreciable and measurable. Thus, 915 periods during the first part of the twenty-four years would be completed in 4575.42 days, and during the second part in 4576.27 days.

It is evident that minute changes in period will thus become readily measurable when the star has been regularly observed over an extended space of time.

In the case of a few stars secular variation of a distinctly circular type has been observed. That is the period decreases, increases, and then returns again to its starting point.

The most remarkable star of this class is U Carinæ, whose average period is 38.7647 days. Its range of variations is 6.7 m. to 7.8 m. It may be of interest briefly to state the nature and extent of the variation to which this star's period is subjected.

The variation of U Carinæ was discovered at Lovedale in 1891, and since then it has been under continuous observation up to the present date. Its rise to maximum brightness is extremely rapid. Thus, instead of determining its period from maxima points, I have preferred to determine it from dates when the star passes through a definite brightness on its upward curve.

The following table sets forth the data connected with the maxima dates thus determined. Column 1 is the rotation number: column 2 gives the number of periods counting from the

epoch of first maximum in 1900; column 3 gives the number of maxima used to obtain the mean period for the year; column 4 gives the mean observed maxima for any one year, all the observations of the year being combined to obtain this mean; column 5 gives computed maxima from the elements.

$$2415032.60 + (38^d.765)E;$$

and column 6 gives the residuals (O-C).

The remaining two columns, 7 and 8, will be referred to later.

1. Ret. No.	2. Epoch.	3. No. of Maxima.	4. Mean observed Maxima.	5. Mean computed Maxima.	6. (O—C)	7. Final computed Maxima.	8. (O—C)
1	—80	5	2411932.17	2411931.40	+0.77	2411932.14	+0.03
2	72	4	2242.22	2341.52	+0.70	2242.27	—0.05
3	62	8	2629.94	2629.17	+0.77	2629.86	+0.08
4	53	7	2978.64	2978.05	+0.59	2978.63	+0.01
5	44	3	3326.90	3326.94	—0.04	3327.36	—0.46
6	33	6	3753.51	3753.35	+0.16	3753.53	—0.02
7	— 6	7	4799.53	4800.01	—0.48	4799.62	—0.09
8	+14	6	5575.10	5575.31	—0.21	5574.74	+0.36
9	41	5	6621.02	6621.97	—0.95	6621.61	—0.59
10	51	2	7009.41	7009.62	—0.21	7009.46	—0.05
11	71	5	7785.45	7784.92	+0.53	7785.19	+0.26
12	89	4	8482.95	8482.69	+0.26	8483.28	—0.33
13	97	6	8793.67	8792.81	+0.86	8793.46	+0.21
14	107	2	9181.08	9180.46	+0.62	9181.15	—0.07
15	118	7	9607.10	9606.87	+0.23	9607.51	—0.41
16	124	3	9840.14	9839.46	+0.68	9840.03	+0.11
17	137	2	2420344.14	2420343.41	+0.73	0343.75	+0.39
18	+146	3	0692.08	0692.29	—0.21	0692.44	—0.36

If now the residuals (O-C), set forth in column 6 be plotted down, the secular and circular character of their departure from the mean will be at once evident. It will appear that the cycle is completed in 180 periods, or 6978 days, the amplitude of variation being 0.65 days.

We have, therefore, as a new determination of the elements of U Carinæ, the following:—

$$\text{Max} = 2415032.68 + 38.7647E$$
$$+ 0^d.65 \cos (212^\circ - 2^\circ E).$$

The computed maxima determined from these elements are given in column 7 and the corresponding residuals in column 8.

If we compare the values in columns 6 and 8, the nearness with which the final elements given above are an interpretation of the light changes of the star will be manifest.

The interpretation, put in words, is this: The star U Carinæ varies in a mean period of 38.7647 days. But this period is constantly changing between the limits

38.73 days and 38.79 days,

all the changes being completed in 180 periods,

or 6978 days.

Of the direct and immediate cause of such variation of period as that of U Carinæ we know practically nothing.

When a period is uniformly increasing or decreasing, one of two causes may be in operation, or perhaps both. The matter of the star may be growing steadily less in bulk, due to the constant attrition of a near companion.

Or tidal friction, due to the mutual attraction of the two bodies, may accelerate or retard the period of revolution, according to the relation of the period of revolution to the period of rotation of the component stars.

But where the variation is circular in character, there is more difficulty in reaching a reasonable explanation.

If we imagine the orbit of the binary star to be sensibly elliptical, then binary revolution, with its corresponding tidal action, must produce certain changes in the form of the orbit. These changes will become manifest in an alteration in the light period of the star.

Or we imagine such a system as U Carinæ to revolve round a large and central body in a period of 19 years. The variation in period, 0.65 day, would then be a measure of the radius of the system.

The difficulty here is that we have to imagine a central body three thousand times more bulky than the sun.

Whatever be the explanation, we are at present only groping dimly towards it. But we are sure of this, that the facts we obtain will one day be of service in definitely ascertaining and defining the causes which produce variation in the period of such stars at U Carinæ.

It is in this expectation that the present brief exposition of the light changes of U Carinæ are offered.

Active Principles of South African Plants.—The *South African Medical Record*, of 13th November* contains a paper read by Dr. C. F. Juritz before the British Medical Association, Cape of Good Hope (Western) Branch,on the 27th August, on "The urgency of a definite forward movement in the study of the active principles of South African Plants."

Radium in Japan.—Dr. Ishidzu, of the Tokyo Hygienic Laboratory, has been investigating the hot and mineral springs of Japan with a view to ascertain the quantities of radium which they contain. It is reported that, as a result of his investigations, he considers Japan to be the richest radium country in the world. Considerable proportions of radium are declared by Dr. Ishidzu to be present in the waters of a mineral spring in the Yamanashi Prefecture, and radium-bearing water also occurs in another spring at Chuggoka.

* (1915) 13 [21].

AN INQUIRY INTO THE DERIVATION OF CERTAIN SOUTH AFRICAN PLACE-NAMES.

By Rev. Charles Pettman.

I propose in this paper to discuss a few of the place-names of this country which have given rise at one time and another to no little controversy as to their origin. It will be remembered by those who were present last year, that the paper on "The Place-Names of South Africa" which I had the honour of submitting to the Association, evoked a very interesting discussion as to the derivation of the name Bloemfontein, which the paper said was "redolent of flowers and springs." It was contended, in opposition to this view, that the name was derived from a certain Jan Blom, who was, at the latter part of the eighteenth or the beginning of the nineteenth century, a fugitive and outlaw from the Colony. In early days, with his band of Bushman, Koranna, and Hottentot marauders, he was said to have established himself at a certain spring, which became known as Jan Blom's Fontein; it was asserted, further, that this name subsequently became Bloemfontein, and that Jan Blom's Fontein and Bloemfontein were one and the same place.

Let me say at once that there is no question as to the existence and outlawry of the man Jan Blom, nor as to his having established himself with his robber band at a certain fountain, nor, further, as to the fountain having been known as Jan Blom's Fontein; the points to be decided are, whether Jan Blom's Fontein and Bloemfontein are identical, and whether the name Bloemfontein originated in the name Jan Blom's Fontein.

It was not possible for me at the time to advance all the reasons which decided me in favour of the derivation I suggested, but to show that it was based upon something more than merely æsthetic leanings I would like to submit the following points for consideration. I confess that I should be somewhat diffident, in view of the high authority quoted against the flower derivation in the discussion referred to, but I cannot convince myself that it is wrong; in fact, further enquiry has strengthened the conviction that the flower and spring derivation is the correct one.

It will help to solve the difficulty perhaps if we can secure two or three fixed points on the map concerning which there is no uncertainty; let us try. There is no question as to the locality of Griquatown (formerly known as Klaarwater); further, the map shows that Kuruman (named by early travellers Lattakoo) lies almost due north of Griquatown; and further, it shows a mountain on the road from Griquatown to Kuruman lying slightly west of the line between the two places, known as the Blinkklip. With these three points fixed, and remember-

ing that Bloemfontein lies nearly 200 miles to the east of Griquatown, there should be no difficulty in locating Jan Blom's Fontein.

The traveller Lichtenstein*, whose travels covered the years 1803-1806, when on a journey to the Bechuanas, shows that he passed from Jan Blom's Fontein to Blinkklip in a few hours. They had camped at Jan Blom's Fontein, and on leaving it he says:—

> A considerable hill, with a high conical summit, was the first object worthy of remark that presented itself as we proceeded on our way. . . . The colonists call the mountain Blinkklip (glittering rock).

Campbell† tells us that he left Klaarwater (Griquatown) by wagon for Lattakoo (which was a little beyond the present Kuruman) at 4 o'clock p.m. on the 15th June, 1814, and that on the 17th June, at 11 o'clock a.m., he reached Jan Blom's Fontein. He says:—

> This fountain derived its name from a person who died about fourteen years ago, who was a runaway from the Colony, and put himself at the head of many Bushmen, Corannas, and Hottentots, and lived on the plunder of other kraals. As he resided chiefly at this fountain, it was called by his name.‡

Leaving Jan Blom's Fontein at 2 o'clock p.m., Campbell continues:—

> At four we halted at Blink Fountain, at the bottom of Blink (or Shining) Hill.

Blink Hill is Campbell's rendering of Blinkklip, the name by which the mountain is still known.

Burchell§ says that on the 17th June, 1812, he

> arrived at a spring where there was still abundance of good water. This was called Bloem's Fontein after a man named Jan Bloem, who had formerly resided in the Colony, but who stationed himself at this spring, and continued for some years to lead a lawless life.

At this spring a buffalo was killed by some member of the party, which was cut up and dried. Burchell continues:—

> 18th.—As the business of cutting and drying our buffalo-meat had detained us till a late hour, we advanced but a few miles, and halted for the night at the foot of a hill known to the Klaarwater Hottentots by the name of Blink-klip (Shining Rock).

These quotations go to prove that the Blinkklip spoken of is to the north of Griquatown, on the road to Kuruman, and that Jan Blom's Fontein would be from six to eight miles from the Blinkklip. Bloemfontein lies, as we have said, nearly 200 miles in a direct line to the east of Griquatown, and supposing that it had then been in existence as a kraal or dorp, was that much out of Campbell's and Burchell's line of travel, and would be much the same distance from the spring then known as Jan Blom's Fontein, to say nothing of the short time (two days) in which Campbell trekked by wagon from Griquatown to Jan Blom's Fontein.

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* 2, (1815) 271-275.

† Travels in South Africa (1815), 224.

‡ P. 230.

§ "Travels in South Africa" (1824), 249-255.

I can find nothing anywhere to substantiate the statement that the present site of Bloemfontein was at any time the headquaters of the outlaw Jan Blom, and can, from the above data, come to no other conclusion than that Jan Blom's Fontein and Bloemfontein are two quite different localities.

Then, with reference to the name Bloemfontein, we have the explicit statement made in a letter written by Mr. G. H. Warden (son of the Major Warden who was British Resident in the Orange River Sovereignty), and published in the Bloemfontein *Friend* in May or June, 1912, that his father bought the farm in 1846 from one Jan Britz, and

> gave it the name of Bloemfontein, owing to there being so much wild clover; the valley above the fountain was covered with wild clover.

The above facts appear to be conclusive, and to prove that the name Bloemfontein *is* "redolent of flowers and springs," and is in no way connected with the marauder and murderer, Jan Blom.

(It may be observed here that there was a place called Bloemsfontein near the Tanqua River, in the northern part of what is now the Ceres district. Borcherd,* who was a member of an expedition which left Cape Town for the interior on October 1st, 1801, tells us in his itinerary that on the 10th October they proceeded from

> Tanquas passing barren country and the Gousbloemsfontein, Bloemsfontein, Windheuvel, and Modderfontein.†

There is also a Bloemfontein, marked on the map of South Africa in the *Times* Atlas, to the north-west of Upington.)

Another name of interest is Walvis Bay. The recent Government announcement that the bay, which was retained by Great Britain when Great Namaqualand was handed over to Germany, was to be known henceforth as Walvis Bay, gave rise to no little discussion in the public Press and elsewhere. It was contended by some that it should have been Walwich Bay. I remember reading somewhere—I regret that I failed to make a note at the time, but I believe it was in an early volume of the first series of the *Cape Monthly Magazine*—that this bay had been called Walwich Bay after the captain of a whaler which frequented the bay. But I am satisfied now that the earliest form of the name was Walvisch Baai. Just how the corruption Walwich came into existence I have not been able to ascertain; it appears, however, to be due to the sailor.

The name Walwich seems to have been applied to this bay over a century ago. Certainly in Owen's "Narrative of Voyages,"‡ two forms of the name appear on the same page; in the text the name is spelt Walfisch, while at the head of the page it is spelt Walwich; this is indicative of the confusion which then existed. But the latter name, Walwich, seems to

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* "Auto-Biographical Memoir" (1861), 4.

† The traveller Thomson also mentions this Bloem Fontein (1827), 218.

‡ 2 (1833), 228.

have been in use some thirty years before that, for Mr. John Noble, who had been appointed to examine old papers relating to the affairs of the Cape of Good Hope, which were preserved in the Public Archives, London, in his Report to the House of Assembly, says that among papers dated from 1795 to 1802-3, he found one entitled

"Report of H.M. Sloop *Star*," having examined coast northwards and found several bays affording good shelter and excellent anchorage, but destitute of wood and fresh water, among those mentioned being Walwich Bay, in 22° 15".

Knowing Mr. Noble as well as I did, I cannot think that a man so careful and exact would allow himself to alter the spelling of the name, but would give it as it appeared in the document mentioned. If this is so, then we can trace the name Walwich Bay to 1803 at least, and apparently to a sailor origin.

But I have been able to trace the name Walvisch Baai to twenty years beyond that—1782. In 1792 the bay was taken possession of for the Dutch by Chevalier Duminy as Walfisch Baai, but in Rochette's map, dated 1782, the name Walvisch stands opposite this bay, and I am satisfied that this is its earliest form.

The name has assumed no small variety of forms—Walvisch, Walwich, Walfisch, Walfish, Walwish, Walviss, and now it is to to be Walvis. Theal says that it was also called by sailors Woolwich Bay, but I have found no trace of that form. Neither have I been able to find on any map or chart available to me the name Bahia das Baleas (Bay of Whales) which Theal says the Portuguese gave to the bay, and which he further asserts "the Dutch translated into Walfish." It would be interesting to know where this name appears. The only references to whales that I can find in the nomenclature of the features of the West Coast of the sub-continent are the following:—(1) According to M. J. Codine,* the name Golfo de Balena appears twice in the map of Martellus (1489), once slightly to the north, and once to the south of Angra Pequena. (2) On a map of Africa by John Senex, London (no date, but about 1719), there is a Gulf d'Baleines, south of Angra Pequena. (3) On the map of South Africa in the *Times* Atlas there is a Whale Bay, also to the south of Angra Pequena.

So far as I have been able to trace the Portuguese name of this bay, it is invariably called Angra do Ilheo or Angra dos Ilhros, though this name appears to have been given originally by Bartholomew Diaz to the bay subsequently known as Angra Pequena, which lies much farther south.†

M. J. Codine‡ points out that Barros also gives this name Angra dos Ilhoes to Angra Pequena:—

* "Extrait du bulletin de la Société de Geographie," Janvier, Fevrier et Mars, 1876, Paris.

† Vide Major's "Prince Henry the Navigator." (1868), p. 343.

‡ "Extrait du bulletin de la Société de Geographie." (1876), 28, note (5).

Le nom Angra Pequena figure déjà sur la carte de Gaspar Viegas de 1534 bien que Barros l'appelle Angra dos Ilheos qui lui convient beaucoup mieux.

That there would be some confusion and difficulty in the identification of features on the coast in the early days can be understood when it is known that beside the duplication of the name Golfo de Balena mentioned above, there are also marked on the west coast on the map of Martellus (1489) no less than three Serra Pardas (Grey Mountain)—the *first* slightly to the south of Angra das Voltas, the *second* to the north of that bay, and the *third* a short distance to the north again.

Another name of interest is Algoa Bay. . Theal, in a footnote,* says:—

In the Esmeraldo de situ Orbis of Duarte Pachaco, written before the death of King Manuel, a bay named Alagoa is mentioned, which is said to have been so called on account of a lake which was there in a marsh. It is described as having a small island in it covered with seals and sea-birds, but its position is given as fifteen leagues east of the Watering Place of S. Braz, that is, the locality of the Knysna inlet. This designation for that particular sheet of water was probably lost soon afterwards, as no other trace of it is to be found, and it does not appear to have had any connection with the naming of the present Algoa Bay.

The name was next given to the opening in the coast now known as Plettenberg Bay—this would appear from the maps published in 1502 by Nicholas de Caneiro and by Cantino, on which Alagoa Bay is marked to the west of Cabo de San Francisco. According to Theal, the original name given by the Portuguese to the present Algoa Bay was Bahia de Roca (Rocky Bay), which it bore till 1548, when it became Bahia das Lobos (Seal Bay). But in 1575, after Perestrello had made a new survey of the coast, the name Alagoa was transferred from Plettenberg Bay to the present Algoa Bay.

Purchas† distinguishes between the two bays thus:—

Beyond the Cape or Point of the *Needles* there are many competent Harboroughs and Hauens, the principall whereof is Seno Formoso, the Faire Bay (*i.e.,* the present Plettenberg Bay), and Seno del Lago, the Bay of the Lake: For there the sea maketh a certaine Gulfe, wherein are sundry Ilands and Ports; and somewhat beyond there runneth into the Sea the River of Saint Christopher (St. John's River) and at the mouth thereof there lye three prettie Ilets.

From Perestrello's survey (for a period of nearly 200 years) Algoa Bay continued to bear the name Alagoa Bay, but at the end of this period some confusion again appears to have arisen, for on the maps in Sparrman,‡ Paterson,§ and Le Vaillant,|| the Keurboom River is made to flow into an Algoa Bay considerably to the west of the present Algoa Bay. According to these maps, after being known as Alagoa Bay for a period of 200 years, the bay suddenly becomes nameless, and Plettenberg

* "The Portuguese in South Africa." (1896), 131.
† "His Pilgrimes," book vii, chap. iv, sect. 6, 1625-6.
‡ "A Voyage to the Cape of Good Hope" (1785).
§ "Narrative of Four Journeys into the Country of the Hottentots and Caffraria" (1789).
|| "New Travels into the Interior Parts of Africa" (1796).

or Formosa Bay once again becomes Alagoa Bay; while Cape Recife, the western point of Algoa Bay, becomes Cape Padrone. The only notice taken of the present Algoa Bay is that in Le Vaillant's map the note is printed in the bay: "Sparrman's Bank —Good Anchorage."

Then at a date fourteen to twenty years later the bay is marked on some of the English maps as Zwartkops or Zwartkops River Bay, and in others as Zwartkops or Algoa Bay, so that it was not until somewhere about the time of the arrival of the British Settlers in 1820 that the name Algoa Bay was permanently affixed to the bay which now bears it.

Many features of our coast and country have changed their names in the course of the years, but I know of no other that has borne four distinct European designations as this bay has done—*viz.*, Bahia de Roca, Bahia das Lobos, Zwartkops or Zwartkops River Bay, and Algoa Bay. Admitting the prior claim of Plettenberg Bay to this name, one neither anticipates nor desires any further change.

Theal makes no reference to the name Alagoa Bay having been borne by the present Plettenberg Bay in his "The Portuguese in South Africa," but says that the name was transferred from the present Delagoa Bay to our Algoa Bay:—

> The bay—previously Bahia da Lagoa—now took the name among the Portuguese of Bahia de Lourenzo Marques, though to all the other Europeans it remained known as Delagoa Bay, and it is still so called. The old name was transferred to the curve on the coast now called Algoa Bay, but the exact date of the transfer, by what individual it was made, and the cause that prompted it, cannot be ascertained.*

This is all so beautifully indefinite that it fails to be convincing; the name appears to have been applied to three different bays in the form Alagoa, but that it was transferred to any one of these from the Bahia da Lagoa, as asserted by Theal, seems somewhat dubious, seeing that the name was borne by one of the three as early as 1502, and the name Bahia da Lagoa was not supplanted by the new name Bahia de Lourenzo Marques until 1544.

This name has also suffered at the hands of the map-makers. It appears as Alagoa (an old form of Portuguese Lagoa, lake, lagoon), Lago, Agoa, Lagoa, Algoa. In Kolben's map† the name Baye de la Groa is given to what is now called Mossel Bay, with Bay St. Blazy printed immediately underneath it, as though it were intended to be regarded as another name of the same bay, and in another map‡ it appears as the Bay d Kagoa.

From what has been said it will be seen that the statement that Algoa Bay was so-called because the Portuguese took their route from that locality on their way to Goa, and that Delagoa Bay was so named because land was generally made thereabouts

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* P. 131.

† "Beschreibung des Vorgebürges der Guten Hoffnung" (1745).

‡ By I. S. (? John Senex) and inscribed to the Marquis of Annandale. n.d.

on their return from Goa, cannot be maintained; it is another example of Folk-Etymology. On the other hand, it has to be said that the name seems to have been applied to the present Plettenberg Bay and to Algoa Bay without any reference to its etymological meaning, for, so far as I know or can ascertain, neither of these bays has a lagoon or lake on its shores to which the name could refer.

The derivation of the name Muizenberg may not have anything to do directly with the *ridiculus mus*, but indirectly it is to be traced back to the little animal. In the "Report of the Keeper of the Archives, Cape of Good Hope, for the year ending 31st December, 1906," the late Mr. H. C. V. Leibbrandt has the following paragraph (9):—

> While on this subject, I may also draw attention to another hatchment in my custody. On one part of the shield are seen three mice, with a fourth mouse as a crest. I have no doubt that this hatchment belonged to Willem Muys, who died in 1755, and at the time of his death, and a considerable time previously, held the important appointment of Commander-in-Chief of the garrison here. During his term of office a small redoubt or fort was built on the narrow passage through which the road passes from Wynberg to Simonstown, and over which road all traffic had to pass, and where an enemy might with some advantage be checked. The little fort was named after him, and though now no longer existing, the spot itself has hitherto retained the name of "Muysenburg," now, for no reason whatever, called and written "Muizenberg." I respectfully draw attention to the wrong spelling, as well as to the names "Valkenburg" and "Elsenburg," which I find are generally written "Valkenberg" and "Elsenberg."

If Mr. Leibbrandt is right in his contention, then the real reference of the name must have been lost, and the name wrongly spelt very soon after Willem Muys' death, as the following extracts from Thunberg* will show:—

> Near Muysenberg (or Mouse Mountain) the wax shrubs (Myrica quercifolia and cordifolia) grow in abundance along the shore.†
>
> There is a farm belonging to the company, and known by the name of Muysenberg, or Mouse Mountain.‡

Thunberg's first volume is dated 1795, but his visit to the Cape of Good Hope was in 1772-3, only seventeen years after the death of Willem Muys, and apparently Thunberg knew nothing of the connection between the place-name and the man, as asserted by Mr. Leibbrandt, while the name in that short period had passed from the fort to the mountain, from *burg*—that is, as Mr. Leibbrandt would have it, to *berg*, as Thunberg has it. This appears the more strange, as the fort must have been in existence, not only when Thunberg was at the Cape, but for some years after; this seems to be indicated by the following passage from Stavorinus:§—

> This ridge makes a bend, from Simon's Bay to the north-eastward, nearly a league and a half in length, and ends at a place where there is a post of the Company, called Muizenberg.

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* "Travels" 1 (1795).

† P. 249.

‡ P. 267.

§ "Voyages to the East Indies" 1 (1798), 44.

Stavorinus visited the Cape in 1774-5.

Supposing Mr. Leibbrandt's contention to be correct, it only means that the relation of the names Muizenberg to the animal is one degree further removed—for that William Muys himself recognised that his surname was derived from the animal is obvious from the appearance of the three mice on his hatchment and one on the crest. We need have no surprise at this origin of his surname, for neither Mous nor Rat, nor for that matter Cat, are unknown as English surnames.*

The origin of the place-name being forgotten, Folk-Etymology has intervened, and to give the name a meaning, some resemblance to a mouse or mice has been seen or imagined in the rocks on the mountain's summit.

Lieutenant Paterson† spells the name "Moesen Berg." Lichtenstein is the only early writer whom I have found, who spells it "Muysenburg."

Duivelsberg, which English Africanders have turned into Devil's Peak, it has been said, is a corruption of Duivenberg (Dove or Pigeon Mountain), and that it received this name because of the numerous doves and pigeons of which it was the haunt. This suggestion appears to be one of comparatively late date, for except in a few recent works, I have not found it anywhere in print, nor anything that would support it as far back as I have been able to trace the name. The suggestion appears to be a bit of Folk-Etymology originating in well-intentioned scruples or ignorance as to the how or why of the name.

The two names Windberg and Duivelsberg seem to have run concurrently for some time—the former being apparently the older; for Kolben‡ calls it "Der Wind- oder Teufelsberg"; then in "Historische Beschryving der Reizen," etc., printed by Pieter de Hondt, 1749, the name "Duivelsberg" is stated to be a sailor's name for the mountain ("Den Matrooz genoemd Duivelsberg," p. 201.)

Thunberg,§ whose book appeared in this edition 22 years after his visit to the Cape, calls it "The Devil's Mountain (Duyvelsberg)"; and on a map undated, but apparently at the latter part of the 18th century, this note is to be found:—

The Devil's Hill, supposed to be so called from the furious winds that issue from thence when the top is covered with a white cloud.

If it is a sailor's name as suggested above, it would, most likely, refer to "the furious winds that issue from thence," but it may, at the same time, be reminiscent of a name which the Cape itself is said to have borne at one time, *viz.*, "Capo Di

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* *Vide* Bardsley's "English Surnames."

† "Narrative of Four Voyages" (1789), 6.

‡ "Beschreibung des Vorgebürges der Guten Hoffnung" (1745), 210.

§ 1 (1795), 101.

Diab," or Devil's Cape. Unfortunately, I have not had access to Humboldt's works, but in Juta's "The Cape Peninsula"* the following passage occurs:—

> We climbed higher and were soon in the shadow of the Devil's Peak or Doves' Peak. The name "Devil" must have drifted from the "Cape" to Wind Mountain. "Windberg" was the ordinary name for the Peak, and "Devil's Cape" was the name given to the Cape many years before Diaz's ship was driven round into the Indian Ocean. Humboldt, the German traveller, has interesting information about this name. He says that on Fra Mauro's chart, published between 1457 and 1459, the Cape of Good Hope is marked "Capo Di Diab."

Mr. Scully† says:—

> This name ("the Devil's Peak") used then to cause great scandal to the Dutch colonists—the term being an unconscious perversion by the English of the original name of "Duiven's" or "Dove's" Peak.

But this statement does not appear to be borne out by the facts, the name Duivelsberg having been used of this mountain three parts of a century, at least, before the Cape passed into the possession of Great Britain. By the English the Devil's Peak was first called Charles Mountain, as the Lion's Hill was called James Mountain, but as we know the Dutch name in each case prevailed, and Duivelsberg became in English the Devil's Peak.

The name Roggeveld, as applied to a considerable tract of country in the Western Province, intersected by a chain of mountains known as the Roggeveld Bergen, has generally been regarded as embodying the Dutch word *rog*, rye; but a friend writing to me some time ago questions this, and says: "Roggeveld means, I am sure, 'rough country.' Rye will not thrive there." That rye will not thrive there appears to be perfectly true, but that does not make Roggeveld mean "rough country." The fact is, as I have subsequently found, the reference of the name is not to the cultivated Rye at all, but to a plant which, in suitable seasons, is said to grow there in some profusion, and is known to the Dutch as "Wilde Rog" (*Secale africanum*), as appears from the following passage from Thunberg, who visited the locality in 1774:—

> Here the country was called the Lowermost Roggeveld, not because it lies lower than the other Roggevelds (Ryefields), but because it lies farthest from the Cape. These as well as the others have been so named from a kind of rye which grows wild here in abundance near the bushes.—Thunberg.‡

Lichtenstein, whose visit to the Cape extended from 1803 to 1806, who also travelled through the Roggeveld, writing of the district, says:—

> Rye (roggen or rocken) is not cultivated here, though the name of the district might lead to the supposition that it was a principal object of cultivation; but the truth is, that the name is taken from a species of grass which grows very much among the clefts, resembling rye, and which the colonists call wild rye.§

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* (1910), 43.
† "A Vendetta of the Desert" (1898), 92.
‡ **2** (1796), 168.
§ Lichtenstein, **1** (1812), 100.

I can find nothing anywhere to suggest that the name refers to the rough character of the country, though reference is made to that feature by more than one of the early travellers.

There is a very general idea abroad that the ill-omened name "Slachters Nek" had its origin in the terrible execution of the men who were condemned to death because of their participation in what is known as the Bezuidenhout Rebellion. But the place had been thus named several years before these men were executed. Originally, it was known as Doorn Nek or Van Aardt's Poort; it lies not far from the main road between Cookhouse and Somerset East. This was the locality in 1811 of the murder by the Kaffirs of Mr. Stockenstrom, the Landdrost of Graaff-Reinet, who, with eight farmers forming his escort, was treacherously killed by the Kaffirs during an interview with them, in which he was endeavouring to dissuade them from war. Information being brought to the Kaffirs, while the discussion was in progress, that hostilities had already commenced, and that blood had been shed, they fell upon the Landdrost and his escort and murdered them all. It was on account of these murders that the place was given the name "Slachters Nek."

When this place was made the scene of the execution of those who were condemned to death for their participation in the Bezuidenhout Rebellion, 1815, it gave to the name Slachters Nek a still more sinister significance, and the hatred of the Dutch against British rule, intensified by these executions, became deep and lasting, and found constant expression in the mere repetition of the name.

In spite of the utmost carefulness one does not always escape the pitfalls that lie in the path of the student of Place-Names; as a result he finds it necessary sometimes to revise his conclusions, and learns by experience that it is safest never to take the current explanation of a name for granted. Finding the name Kowie printed in some fairly early missionary and other works with an initial C *, it appeared to corroborate a statement made to me 35 years ago, by a resident of the place, that the name was derived from a Dr. Cowie, who, in the early days of the Settlement, was the District Surgeon of Lower Albany, and who, with his companion, Mr. Benjamin Green, succumbed to fever on their return from an exploring expedition to Delagoa Bay in 1828. This date should have been sufficient to put one on his guard, and have given one to see the necessity of looking elsewhere for the derivation of the Place-Name. The fact is, the name Kowie was in use long before Dr. Cowie had arrived on the scene; for in 1812 Lieutenant-Colonel J. Graham, writing to the Colonial Secretary, speaks of "the source of the Kowie River"; then, in 1819, Earl Bathurst sent lengthy instructions out to the Cape as to the territory to be

* Methuen: "Life in the Wilderness" (1848), 31. Smith: "South Africa Delineated" (1850), 38, 39.

occupied by the Settlers of 1820; starting at Grahamstown, it was to include the country lying between the Kowie, Kasonga, and Kariega Rivers. The name must therefore have been in existence before the arrival of the Settlers. Further, a petition was sent to Earl Bathurst by the Settlers in 1823, in which the name is spelt with a K, which would certainly not have been done had the river been named by them after the doctor.

The derivation of the Place-Name from the doctor's surname would thus appear to be another example of Folk-Etymology—attempting to give a meaning to a name from which the original meaning had departed.

Like most of the other river names along this part of our coast, there would appear to be little question as to its origin; among the Kaffirs the river is named i Qoyi (palatal click); this is almost certainly the Kaffirised form of an earlier Hottentot name. One old Hottentot told me years back that the name meant noisy, rushing, and Krönlein gives the Namaqua word ‡ Kuwi as meaning to make a noise, to roar, and, as the click is the same as that in the Kaffir name, the three words Kowie, i Qoyi, and ‡ Kuwi may find a meeting place at this river.

Another name of Hottentot origin that is of interest is Knysna; it is of interest inasumch as two distinct meanings have been given to the name. It is commonly explained as meaning a fern leaf, or having reference to the great number of ferns growing in the neighbourhood; but in a paragraph in *De Kerkbode**, it is said that the name has reference to the two steep kranzes between which men must pass to the little port inside. The old Hottentots, it says, spoke of a straight down cut as 'tny or 'tnaai; and because the two kranzes run straight down into the sea, as if they had been cut off with a huge knife, the place was named by the Hottentots 'tnaai 'tnaai, each part having an initial click. This derivation would appear to be the more likely, judging from the fact that the wilder features of nature seemed to impress these peoples before any other. It would have been much more satisfactory, however, if the writer could have given the particular click used, it might then have been possible to trace the name with some degree of certainty to its origin. I can only hesitatingly suggest that the name may be connected with the Hottentot word ! gao || na, meaning, to cut off.

There is a curiously-shaped mountain on the railway between Rosmead and the Stormberg known as the Thebus Berg. Many of the residents of the neighbourhood, if asked the meaning of the name, will direct your attention to the box-like shape of the mountain, and ask if any name could be more appropriate. It is, say they, the exact reproduction on a magnificent scale of an old-fashioned tea-caddy (D. theebus). Others will tell you that the mountain was known originally as the "Phœbus Peak"; that the original diagram of the farm, which was at one time in

* November, 26th, 1914.

a local office, bears the name Phœbus, and that the mountain was so called because it is the first point in that locality to catch the light of the rising sun, and that Thebus is a corruption of Phœbus. But when one finds on Lichtenstein's map that this and the neighbouring mountains are marked as the "Taay Bosch Mountains" (Taaibos, *Rhus obovata*), quite another derivation is at once suggested, and a derivation that one cannot help thinking is a more likely one than those previously mentioned.

Without venturing to assume that the derivations suggested above are in every case indisputable, it may be pointed out that there are other South African Place-Names, the origins of which might possibly be elucidated by a little careful research, which are at present somewhat of a mystery, *e.g.*, Ceres. I have neither found nor heard anything that could be regarded as definite or conclusive as to its origin. Three different derivations have been suggested: (1) That it was the name of a vessel which was wrecked in Table Tay, and that the name was transferred to the place by some person who was in some way interested in both the vessel and the place. (2) That the name was given by some patriotic Scot from the neighbourhood of Ceres, in Fifeshire. (3) That it is one of the few classical names to be found in our South African nomenclature, that the place was named after Ceres, the goddess of agriculture and fruits. One could wish that the last suggestion were the origin of the name as here applied, the appropriateness of which, for so fruitful a locality, would be at once apparent.

Is it too much to hope that this brief enquiry into some of the puzzles of our South African Place-Names may evoke somewhat of the interest in this interesting and instructive subject which it deserves?

SOME PROBLEMS OF PHYSICAL CONTINUITY.

By Rev. Sidney Read Welch, B.A., D.D., Ph.D.

In modern science and philosophy the word "continuity" has assumed an importance hardly dreamed of by writers of fifty years ago. Its general meaning has been that of a certain persistence, whether of movement or of being, through successive stages or successive transformations. When theories of evolution were most popular in scientific circles, the persuasion of the existence of some kind of continuity crystallised into a conviction, often held very dogmatically, that there was a greater uniformity in nature than it was ever possible to prove.

But to-day continuity is looked at more from the standpoint of the separate sciences which occupy the intellectual powers of men. In biology we discuss the continuity of life (biogenesis), of cells, of germ plasms, and of variation through small and continued increments in one direction. Psychology sees shadows of the continuum in the operations of the human mind; not only in the continuity of consciousness, which some have regarded as the objective background out of which the more specialised processes of the mind are elaborated, but also in the motor-continuum, which is the physical counterpart of the constant readiness to act, and the memory-continuum, which is sometimes supposed to be integrated by means of the movements of attention. And even the mathematicians claim to have discovered a subtle attribute of the continuum, which had escaped notice until the seventies of the last century, and was revealed by the acute labours of two German scholars, G. Cantor and Dedekind, who were working independently. Lastly, Pragmatism has given continuity an extraordinary extension and a new life, making it the basis of all philosophy.

But at the root of all these new connotations of the word lies the ancient and elementary meaning that it has always had for mankind—the unbroken line, or surface, or volume, that can be seen or felt. Very early Aristotle gave this subdivision of a category a philosophical definition, which was a commonplace of European philosophy for many centuries, in the Latin form in vogue with the Scholastics:

> Continua quantitas est cujus partes ad unum communem terminum copulantur.

It goes without saying that such a vague definition lent itself to various senses. But its most lucid exposition is to be found in one of the minor philosophical works of the great Aquinas,* which we may thus translate:

> We must imagine a moving point (which is the indivisible in a line) which by its motion produces the line, the moving line produces a super-

* "Logicæ Summa," C. III. As far as I know, no English translation of this work exists.

ficies, a moving superfices produces a body, and a moving "now" produces time. These things being so produced and imagined, though indeed they do not so take place in reality, we grasp the aforesaid definition. For if a moving point produces a line, all the parts of the line are united by the point. And since in every part of the line we can in this way imagine a point, to which apart from all other considerations any other particle is constantly related, hence the line is called continuous.

Yet this fundamental, and apparently simple, idea of continuity is full of dialectical difficulties for the philosopher. The most ancient of the problems of physical continuity is one which still puzzles the logicians. Is the continuum in physics a reality, or just a delusion of the senses? More than 2,400 years ago Zeno of Elea appears to have put forward a series of arguments that combated the reality of motion and multiplicity. What Zeno's personal sentiments were we cannot now discover, since the only records of his opinions are in the words of hostile critics—Plato and Aristotle.

But one of his alleged arguments deals a clever blow at the very notion of continuity. It is the well-worn paradox of Achilles and the Tortoise, which every novice in "Logic" has at some time set himself to answer. And the sophism has received a new lease of life in our day on account of the respectful agreement with which it has been revived by Bergson and his followers.

Let us suppose, Zeno might have said, that there is such a thing as continuous quantity, say a racecourse where Achilles, the champion runner, shall race with the tortoise. Give the latter the least possible advantage of a start in the race. Every time that Achilles reaches the point where his slow competitor is, the latter will have moved on a little further. True enough, the tortoise will have gained less and less over Achilles; but since, *ex hypothesi communi* all continuous space is infinitely divisible, it will take Achilles an infinite time to win the race, *i.e.*, he will never win it. And all because you have supposed an absurd thing—that continuous quantity is a real and not an imaginary thing. It is, in fact, a conflict of intellect and imagination, and one must check the fancy by the straight rules of Logic.

Perhaps it might be better to overhaul the logical apparatus of the argument, in order to make sure that everything is quite in accordance with reason. It is quite clear that at no possible point postulated in the premises of this plausible argument can Achilles overtake the tortoise, and, on the other hand, there is an infinite number of such points postulated. Outside infinity, where is one to find new points to save the credit of Achilles?

The most complete reply to this accumulation of sophisms that I have seen, was given by Mr. C. D. Broad,* two years ago. He begins by pointing out that you have not necessarily exhausted all the points in a series, because you take an infinite number of them. You might, *e.g.*, take an infinite number of even numbers, and leave the equally infinite number of odd numbers. It is true enough that at no point given in the construc-

* In *Mind*, April, 1913.

tion of Zeno's argument can Achilles and the tortoise meet. But the possible points of meeting are by no means exhausted by thinking of the points where the tortoise stops before it is overtaken. Outside the large number of such points there may be one or more where the tortoise is actually overtaken.

The whole argument is vitiated by the implicit refusal to consider such a point possible.

This can best be illustrated [says Mr. Broad] by considering a series of numbers instead of one of points, and the real relation of "greater than" instead of that of "beyond." Consider the series whose general term is $2 - \frac{1}{n+1}$ where n can be any integral value including 0. It is clear that its first term is 1. It is further clear that it has an infinite (*i.e.*, indefinite) number of terms. Finally, 2 is greater than every term of the series. Hence if we had an analogous proposition to that assumed by the supporters of the Achilles, we should have to say: "2 is infinitely greater than 1, for it is infinitely greater than every term of an infinite series whose first term is 1." The obvious absurdity of this shows the absurdity of the implicit premises without which the Achilles cannot draw its conclusions.

There is, therefore, no sound reason to hold that our imagination deceives itself or contradicts the higher judgment of reason in holding that the continuum is both a reality and infinitely divisible.

But I am inclined to be grateful to Zeno for the worry that he has caused all the philosophers by means of this ingenious argument. He has taught us to sound some of the hidden depths of simple concepts. Or, to put it in the words of Mr. Wm. James* Zeno,

Gives a dramatic character to the difficulty inherent in understanding intellectually any phenomenon whatsoever of continuous change.

The difficulty applies not only to continuous change, but to every species of continuous quantity.

But when we begin to probe into the nature of physical continuity, we are faced with many of the special difficulties of the infinite. If the continuum were a reality, we are told by the old Greek sophist, you would require an infinite time to traverse it. For it can be divided into an infinity of points; and no matter how small the period of time required to pass one of these points, the time required to pass the whole series would be infinite. Which is absurd: and so also is the notion of continuity into which the eye and the finger decoy us.

The solution of this purely logical knot is nearly as old as the original difficulty. Aristotle,† who preserved the conundrum, has also furnished us with the simplest solution of it: "Now it is not possible to touch things infinite in regard to number in an infinite time, but it is possible to touch things infinite in regard to divisibility; for time itself is also infinite in this sense. So that, in fact, we go through an infinite (space) in an infinite

* Article on "The Philosophy of Bergson," in *Hibbert Journal*, April, 1909.

† "Physics," 6 [2].

(time) and not in a finite (time), and we touch infinite things with infinite things, not with finite things." Hence, if it could really be proved that the continuum is infinite because it is infinitely divisible, it would follow for the same reason that all time is similarly infinite. The two difficulties would cancel one another. For there is no intellectual difficulty in measuring infinite distance by infinite time.

Yet this only brings the difficulty back to us in a more modern form. If we agree to think of continuous quantity as an infinite series of terms, we are faced with all the confusion that arises when we try to imagine what an infinite number is like. It is no question of imagining a series which begins in sight and travels beyond our ken. The infinite series which constitute a definite space of some continuum are all before us at the same time.

A most ingenious attempt has recently been made by Mr. Bertrand Russell* to give an adequate answer to these queries by means of a new theory of infinite numbers. He finds the root of the difficulty in the common notion that we must be able to count a number. "If you set to work to count the terms in an infinite collection, you will never have completed your task" (p. 181). But this possibility of counting is not essential to the reality of number. We know many finite collections, such as "mankind," without being able to count the whole collection one by one; and so, too, infinite collections "may be known by their characteristics, although their terms cannot be enumerated."

After this preliminary statement Mr. Russell sets out to establish what he calls his positive theory on infinity. The need of it arises, or appears to Mr. Russell to arise, from the emergence of infinite numbers in the arithmetic of the continuous.

> The supposed difficulties of continuity all have their source in the fact that a continuous series must have an infinite number of terms, and they are in fact difficulties concerning infinity. Hence in freeing the infinite from contradiction, we are at the same time showing the logical possibility of continuity as assumed in science.†

"What is a number?" Mr. Russell asks. If we count out a certain number of objects, their number is commonly thought to be that of the last object reached in consecutive order. But, says Mr. Russell, that is only true for finite numbers. Where infinite numbers are concerned, counting, even if it were practically possible, would not be a valid method of discovering the number of terms in an infinite collection, and would in fact give different results according to the manner in which it is carried out.

Hence he calls our attention to two differences, which he discerns, between finite and infinite numbers. The latter have a property of "reflexiveness" which the former have not, and

* "Our Knowledge of the External World," Lecture VII, pp. 185-208.
† "P. 155.

conversely, finite numbers are "inductive," whilst infinite are not. A reflexive number he defines as one which is not increased by the addition of 1; "inductive" numbers are all those that can be reached by successive additions of 1. Beyond these are all the infinite numbers.

The first of the infinite numbers has no immediate predecessor, because there is no greatest finite number; thus no succession of steps from one number to the next will ever reach from a finite to an infinite one, and the step-by-step method of proof fails.*

When we have realised the existence of these properties of number, we discover, if Mr. Russell judges correctly, that the supposed contradictions of infinite series are really only shocks to our prejudice, not to sound logic.

But all this necessitates a new definition of "number," which Mr. Russell claims to be the work of a great mathematical genius, Gottlob Trege of Jena. There must be no counting in Mr. Russell's "number," as is obvious from what has been said. In practical life two collections have the same number of terms when there is a one-one relation between all the terms of one collection and those of another. There is a certain similarity between number and colour. "The number of terms in a given class is defined as meaning "the class of all classes that are similar to the given class." This definition is held to have the supreme merit of showing that it is not physical objects, but classes or the general terms by which they are defined, of which numbers can be asserted.

It must be admitted that Mr. Russell feels the full force of the instinctive prejudice that will greet this definition; people will be at first inclined to resent its oddity as well as the peculiar behaviour of infinite numbers. But

Numbers, in fact, must satisfy the formulæ of arithmetic; any indubitable set of objects fulfilling this requirement may be called numbers. So far, the simplest set known to fulfil this requirement is the set introduced by the above definition. In comparison with this merit, the question whether the objects to which the definition applies are like or unlike the vague ideas of numbers entertained by those who cannot give a definition is of very little importance.

From these last sentences hardly anyone will be found to dissent, if the implied facts are accurate. It is undeniable that a definition of number must satisfy the formulæ of arithmetic. But where the formulæ themselves are open to some doubt and discussion, no convincing theory can be built merely upon one interpretation of a debated theory.

And here Mr. Russell seems to have had an experience like to that of the Pythagoreans narrated by himself. These philosophers held that "things are numbers," and they apparently conceived the continuum as a series of measurable atoms with empty space in between. But unfortunately for this philosophical system, Pythagoras discovered the proposition that the sum of the squares on the sides of a right-angled triangle is

* P 197

equal to the square on the hypotenuse. When he came to consider the case of a right-angled triangle with two equal sides, he found himself face to face with the hard fact that the diagonal and either of the sides were incommensurables. For a system of philosophy which placed the essence of the universe in a numerical relation, it was fatal to find two things which refused to be expressed by any possible ratio of numbers.

In a similar way, Mr. Russell takes it for granted that the collection of possible points in any continuum must form a number. But obviously the number of these points cannot be obtained by piling 1 upon itself, no matter how often the operation may be repeated. Our ordinary numerals are quite incapable of expressing this number, because we can always imagine something beyond the largest assigned numeral. This means that no "finite" number can meet the case.

"Irrational" numbers have long been used in arithmetic in order to indicate the ratio of incommensurable lengths.

Accepting the view that a length is composed of points, the existence of incommensurables proves that every finite length must contain an infinite number of points. The property of being unable to be counted is characteristic of infinite collections, and is a source of many of their paradoxical qualities. So paradoxical are their qualities that until our own day they were thought to constitute logical contradictions.*

But what reason is there to assume that the incommensurable is a real number, and not rather a symbol of something that cannot be expressed in numbers? A French mathematician of note, C. A. Laisant,† waxes indignant that anyone should question whether the number $\sqrt{2}$ exists.

Autant se demander si 2 existe, je sais bien ce que c'est que 2 arbres, 2 ânes ou 2 kilomètres; mais 2 tout seul, comme nombre abstrait, n'existe qu'à l'etat de creation du cerveau et de signe représentatif. De même $\sqrt{2}$ a une existence pareille, c'est un signe visible, qui représente une notion nettement définie; c'est la traduction précise d'une quantité concrete, si je l'applique au mètre pour unité, puisque je sais construire la longueur $\sqrt{2}$. La seule différence, c'est que je ne pourrai appliquer le symbole d'un nombre incommensurable qu'a des grandeurs continues par essence, aussi bien que je ne peux appliquer le symbole d'une fraction qu'à des quantités divisibles.

But it is stretching the language of arithmetic too far to say that $\sqrt{2}$ is the exact translation of a concrete quantity. It certainly may represent a definite length in continuous quantity, but in the discrete medium of numbers it can never be fully and accurately defined. The comparison with fractional terms will not do. Fractions define the divisibility of objects in numerical terms that leave nothing to the imagination; but when you have exhausted your physical endurance in defining $\sqrt{2}$ in terms of numerals, you still have room for enquiry.

Ought we not rather to say that the incommensurable number is a mathematical convention which symbolises a physical experience with regard to the "continuous"—*i.e.*, that you can

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* P. 164.

†"La Mathématique," p. 33.

go on dividing it for ever approximating to the actual value of $\sqrt{2}$? The two processes are parallel, but the discrete medium of arithmetic is not flexible enough to express all that can be put into the continuous line.

The mathematician is in fact deceived by the analogies of the physicist and the metaphysician. The scientist deals with continuity as it strikes the senses *in rerum naturâ;* the metaphysician is free to consider all its fundamental aspects. Both can appeal to the possibility of an infinite (*i.e.*, indefinite) number of points in the actual lines they perceive; though they all confess that no available instrument has helped them, or can help them, to produce the infinite series of points, as distinct parts of the continuum, in the way that the microscope breaks up a uniform surface of some sea dust into organic animals.

Mathematics can define the continuous only by means of the numbered points which it is able to postulate as the starting places of its researches. The vital factor in the definition of the mathematical continuum is that it contains points arranged in a certain order. The analogy of the other sciences would indicate that these points are infinite in number. But this infinity (in the sense of "indefiniteness") cannot be turned into an infinite number, with mathematical precision, until the possibility of "counting" such an infinity is shown. To point to "irrational" numbers (numbers which cannot be enumerated) is not so much a proof of the need of postulating the existence of the infinite number as an indication that certain aspects of physical continuity cannot be rationally represented in arithmetic.

And this is perhaps only a particular instance of the warning that the great French philosopher and mathematician, H. Poincare,* gives as to the limits of mathematical speculation.

> L'esprit a la faculté de créer des symboles, et c'est ainsi qu'il a construit le continu mathématique, qui n'est qu'un système particulier de symboles. La puissance n'est limitée que par la nécessite d'eviter toute contradiction; mais l'esprit n'en use que si l'expérience lui en fournit une raison.

The reason in this case would seem to be the need of expressing mathematically the fact that there is no arithmetical equivalent for certain aspects of experienced continuity. For whilst mathematics has done much to lessen the logical difficulties of physical continuity, especially during the last fifty years, it has its own limitations, which cause it to need help from the other sciences and from practical experience, in order to express the full meaning of the continuous.

* "La Science et l'Hypothese," p. 40.

NATIVE AGRICULTURE.

By Rev. John Robert Lewis Kingon, M.A., F.L.S.

The Transkeian Territories, occupying the Eastern portion of the Cape Province, cover an area of 18,181 square miles, and support a total population of 908,706 persons. We have, therefore, 49.98 persons per square mile; of which only 1.08 are European—or, to put it another way, 12.80 acres of land are available per head of population.

In making a study of Native agriculture, one is impressed not only with the magnitude of the possibilities, but also with the extent of the actualities. We are too accustomed to think of the Natives as unprogressive and lazy, and do not realise how much in the aggregate is produced by them in spite of their wasteful and comparatively crude methods, nor, for that matter, how considerably would the production rise if better methods were introduced. In any case, so vast a source of employment (especially in conditions so uniquely favourable) should be carefully fostered and developed in the best interests of the State no less than in the interests of the Natives themselves; and, moreover, if better methods of agriculture were employed, fewer labourers would be required to do the work, and so, more would be set free to engage in other fields of production, while the land would become capable of supporting a larger population than at present is the case.

Before, however, we deal with Native agriculture in its varying aspects, let us see how much land is available, without which there could be no agriculture. This is hardly the occasion to enter into a discussion on land in its relation to the Natives—whether it is to be dealt with so as to secure greatest productiveness, or whether there is a higher and greater use involving the comfort and peace of those individuals who live upon it. In these days, when utility is regarded so highly, it may perhaps be pertinent at least to enquire whether, under certain given circumstances, productiveness should not be sacrificed, so that the ease and enjoyments of the occupants may remain undisturbed. With these questions, however, we are not now concerned, for our field of enquiry is confined to the amount of land available for agricultural purposes, and the use to which it is being put.

The total extent of the Transkeian Territories (including Pondoland) amounts, roughly, to 5½ million morgen (about 11 million acres). The land lying fallow, together with the pastoral and agricultural land, amounts to some 3,096,659 morgen (about 6½ million acres), the greater part of the remainder being made up of mountain areas impossible of use in these ways.

In the surveyed districts this land is held on individual title, but most is still held under communal tenure, as will be seen by consulting Table A.

TABLE A.

Districts.	Bantu Population.	Surveyed.	Whether District Council or not.	Agricultural Land.			Schools.	Teachers.	Children	
				Arable Morgen.	Pastoral Morgen.	Fallow Morgen.			Male.	Female.
I. **Transkei**:										
Butterworth ..	20,890	S	Yes	2,048	46,075	92	27	67	676	1,055
Idutywa ..	30.277	S	Yes	2,938	65,720	23	28	49	726	767
Kentani ..	36,468	..	Yes	2,536	63,792	79	45	61	798	514
Nqamakwe ..	36,652	S	Yes	3,560	74,688	64	63	149	1,499	2,569
Tsomo ..	20.749	S	Yes	1,730	45,915	40	35	85	722	1,304
Willowvale ..	41,324	..	Yes	3,886	78,591	31	48	89	1,002	1,031
II. **Tembuland:**										
Elliotdale ..	28,036	..	Yes	2,409	43,620	52	4	5	63	47
Engcobo ..	61,063	..	Yes	5,682	156,588	42	55	98	1,559	1,322
Mqanduli ..	35,183	..	Yes	4,835	73,710	42	35	49	703	442
St Marks ..	38,438	..	Yes	3,809	68,678	133	38	62	841	1,048
Umtata ..	43 635	In process	Yes	6,524	91,125	835	54	73	1,219	973
Xalanga ..	15,170	..	Yes	3,303	53,236	25	27	42	618	843
III. **East Griqualand**:										
Matatiele ..	36,455	..	Yes	12,778	199,028	3,194	43	68	1,000	1,150
Mount Ayliff ..	18,835	..	Yes	1,984	55,068	20	22	33	429	489
Mount Currie ..	10,581	..	Yes	25,932	290,965	6,138	23	17	237	245
Mount Fletcher ..	25,820	..	Yes	2,000	138,810	28	40	57	905	747
Mount Frere ..	37,667	..	Yes	7,232	100,350	4	49	110	1,323	1,361
Qumbu ..	33,159	..	Yes	2,816	84,312	13	53	99	1,213	1,548
Tsolo ..	32,646	..	Yes	3,314	95,542	302	52	91	1,194	1,215
Umzimkulu ..	35,603	..	Yes	8,401	169,546	1,463	52	82	1,298	1,211
IV. **Pondoland**:										
Bizana ..	42,366	..	No	5,117	103,791	..	10	13	193	173
Flagstaff ..	27,780	..	No	5,207	61,596	..	16	25	358	409
Libode ..	25,421	..	Yes	2,202	79,116	65	9	11	114	116
Lusikisiki ..	44,015	..	No	10.737	134,281	..	14	16	172	216
Ngqeleni ..	36,648	..	Yes	6,016	63,833	117	17	18	321	243
Tabankulu ..	37,509	..	No	11,121	66,973	33	18	26	253	375
V. **St. Johns** ..	17,888	..	Yes	3,466	49,220	94	7	6	74	66
	879,126			168,352	2.911,384	16,923	933	1,509	19,614	21,621

NOTE.—Population: all Races, 908,706; Europeans, 19,660. Increase on 1904 census = 8·7%

In the course of our investigation let us first turn aside for a brief consideration of the question of the communications in relation to the agriculture of the Territory.

1. Communications.

Naturally the communications of any country and its geographical position affect very closely the commerce and agriculture. Where communications by rail and road are good we may expect the flow of exports and imports to increase steadily, demand reacting upon supply, and supply creating demand; and conversely, where there are few railroads and main roads, and little coming and going, there we would expect a sluggish, heavily moving, trade of small relative dimensions.

Where the transport is dependent upon oxen, anything in the nature of cattle disease on a large scale, or badly made, badly repaired roads, or even a mild drought which affects the pasturage along the road, increases the difficulties already presented by the great distances, and by causing a rise in prices, limits the exports and imports, and prevents the development of trade.

In some lands canals have been used with great success for the transport of goods from place to place, but in the Transkei no voice has yet been heard urging the building of canals. Practical difficulties, such as the conformation of the land and the supply of water, are very great. The future may yet prove that they are not too great. But canals were first built where the conditions were most suitable, and at a time when the motor had not as yet emerged from the visions of the inventor. It seems that the usefulness of the motor as a vehicle of transport is not yet realised, and that we may look forward to developments that will revolutionise our present ideas on the subject. In the census returns of 1911 it was gravely recorded that there were three motors in the Territories. I have been told by the pioneer who first introduced the motor into the Transkei that his car was fitted with solid tyres. To-day, nearly every village has at least one garage, and many of the larger places have at least two and three garages. Cape carts and other horse-drawn vehicles are almost obsolete. It is surprising how many old colonists now regard the orthodox six miles an hour in their cart as a speed impossibly slow, and have betaken themselves to the more expensive but speedier motor.

In this motor invasion of the Transkei we see, and foresee, an expansion of trade, and an all-round advancement of first importance; for the Transkei can never go back to the days when all comings and goings from the centre and the west included of necessity the formidable and even dangerous post-cart journey of some 200 miles to the railway at Kei Road.

Already in the south-west the railway has been constructed across the Kei River, and has, in fact, penetrated to the Bashee.

At no distant date the sight and sounds of the modern train will be heard as far as Umtata—and beyond. The northern border districts have long enjoyed the benefits of the railway. On the east the railways have been pushed forward into the Territories almost as far as Kokstad, and possibly in time we shall see a railway line running inland from St. Johns, and Port St. John a place of some importance.

We may then look forward to the day when the present ox transport will be an interesting relic of the past, and all the commerce of the Territories will be opened up by the speedier transport of rail and motor. Who can say what limits are to be placed on the expansion of trade which will result?

Until the communications are improved, we can hardly expect any great activity in production for the export trade, for to produce more than local requirements demand, would be in present circumstances simply a work of supererogation.

It is therefore no small satisfaction to observe the increasing attention which the Transkeian Territories General Council, and the Pondoland General Council, are giving to the construction of roads and bridges. These are fundamental works of the greatest importance, for if motor traffic is to develop to any great extent, we shall need roads that are more than mere tracks across the veld, and bridges across the principal rivers in order that traffic in the summer months may not be continually delayed and endangered by the flooding after the thunderstorms.

The Pondoland Council authorised the expenditure of more than £6,000 for the construction and upkeep of roads in the years 1912-14, and the Transkeian Council, having jurisdiction over a much wider and much more advanced area, spent considerable sums of money in those three years for a similar purpose. Tables B and C, compiled from official published figures, show how much is being accomplished.

B. THE TRANSKEIAN COUNCIL.

	1. ROADS.		2. BRIDGES.	
Year.	Estimates.	Expenditure.	Estimates.	Expenditure.
1911-12	£13,000	£13,012	£ 28	£28
1912-13	17,000	15,812	18	18
1913-14	17,135	17,611	168	...
1914-15	15,480	...	738 (submitted)	...
1915-16	18,720 (submitted)	...	...	...

C. The Pondoland Council.

1. ROADS.

Year.	Estimates.	Expenditure.
1911-12	£1,500	£775-5-11
1912-13	1,500	1,401-11-3
1913-14	1,900	...
1914-15	2,700	...
1915-16	(not available)	...

Since outbreak of the war expenditure has been cut down to a minimum.

2. Arboriculture.

The traveller in the Transkei is usually impressed by the absence of trees. In certain parts we get the mimosa scattered over the landscape, and in the southerly aspects of the mountains we get magnificent forests in the valleys. Many of the trading stations and mission stations have an acre or two of wattles, an orchard, and perhaps a number of eucalyptus and other trees, and the Government plantations are a permanent object-lesson of what can be done in the way of tree-planting. But, apart from these, it is a rare sight to see a native kraal surrounded by trees. The native has not yet learned how much a full-grown tree represents of the patience, and wisdom, and power of the Creator. His wives and children must walk perhaps eight miles to the forest, and carry home on their devoted heads sufficient for the domestic requirements, but it has never entered into his head to plant a few trees near by, so that all this trouble might be saved. If he wants a few poles for a new roof, he is put to the trouble of the same long walk and the expense of purchase. And what is the secret of all this? The fact is that, broadly speaking, the native is wasteful to an extreme—wasteful of the land he uses, of the lives of trees and animals. It is this wastefulness which has destroyed all the game in the Transkei.

The boys organise regular hunts for the tiny field mice, and few birds fly past without having a club hurled after them, and such trees as there were in early days have been for the most part chopped up for firewood in the same wasteful spirit. It is said that the Transkei was once fairly well wooded. The Forest Department has now stepped in to protect and extend the forests, and while wood may be taken away if it is dry enough to be broken off, no axes are allowed in the demarcated areas.

This wise provision is in the best interests of the people themselves, and protects the forests from wholesale destruction. It is, however, unfortunate that the goats and cattle should be free to wander about in the vicinity of the huts, just where one

might expect trees to be planted; already some have sufficient wisdom to see that it is quite worth while planting, protecting, and watering the young trees until they are strong enough to hold their own against the attentions of goats, and cattle, and drought. How different the Transkei would be if every native kraal had several full-grown trees at hand!

But, even apart from the uses and conveniences of trees near to the dwellings of the people, we must not forget the value of the wood and bark for industrial purposes. For instance, the wattle bark industry may be well developed here, for the wattle grows readily anywhere in the Territory. The importance attached to forestry, and the need for augmenting the supply of wood in view of future needs, has already been realised, and the Transkeian General Council spends large sums of money annually in the conservation and extension of forests, but as yet nothing is done to encourage the individual to plant trees for his own use.

In this matter, as in agriculture proper, the primitive ideas and methods have been allowed to persist even unto this day.

3. The Old Methods.

In the earliest days, when the first missionaries and pioneers entered the country, they found that a wooden implement resembling the paddle of a canoe was used by the natives in the cultivation of their lands. Agriculture was relegated to the women and slaves, while the men engaged in hunting and warfare, never in agriculture. In any case, the tribes wandered about a good deal, sometimes attacking others, and at other times repelling attacks, and consequently, in the uncertainty, cultivation was neglected.

The Rev. William Shaw, in his book* published in 1860, says that

> Multitudes perished by famine, while in some cases small tribes became cannibals, in consequence of the impossibility of obtaining the ordinary means of subsistence. There is reason to believe that during a period of about 18 years, terminating in 1835, not less than one-half of the entire population of the immense region described above was destroyed by these terrific native wars.

Chaka, chief of the Amazulu, living west of Delagoa Bay, trained his hordes and fought east, west, north, and south, over an area of more than 100,000 square miles. From Delagoa Bay to the Griqua country near Orange River, and from the Barutzee country in the north to that of Amampondo on the south, was one scene of war and desolation—*i.e.*, 1820-1835, about.

At this time, then, the women sowed the seed, and removed the weeds from the "cultivated" land, and as the men were away all day hunting, or engaged in warfare, it fell to the lot of the women to protect the fields from the depredations of

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*"The Story of My Mission."

animals and birds. In due course they reaped the harvest, and threshed it by a simple process of beating out the grain with sticks, winnowing it in the wind, and storing it for future use in the curious mealie pits dug out under the cattle kraals.

In this way the mealies could be stored for a considerable time dry and free from the weevil.

But with the advent of the British Government into these territories, there came greater security of tenure, and there was a disposition to take greater care in the cultivation of the fields. Mr. Shaw gives us a delightful little picture* of the introduction of the plough in his district. He writes:—

> When we introduced the plough at Wesleyville, there was no small stir among great numbers of the people, who, although they had heard of such an implement, had never seen it in operation. . . . . The people looked on with great surprise, and followed up and down the field, uttering all manner of exclamations expressive of their astonishment.

One chief, "clapping his hands," shouted to a man on the hillside: "This thing that the white people have brought into the country is as good as ten wives."

The introduction of the plough at once created a landmark in the history of native agriculture, for the plough was drawn by oxen, and no woman was allowed to work with the cattle, and consequently all the ploughing was done by the men. But the other work, such as hoeing and reaping, remained in the hands of the women. The invariable crops were Kafir corn, mealies, and pumpkins.

Writing in 1822, the Rev. John Campbell, of the London Missionary Society, who had made extensive travels in South Africa, says:—

> Though fond of potatoes and other European articles of food, they have not been prevailed on to raise them, because to plant such vegetables would be an alteration or an encroachment upon the old system, which they venerate as established by their *wise* forefathers; . . . they suppose that by planting them they would be rendered unclean, and the falling of rain be prevented.

This attitude has been, and remains to-day, the root cause of the unprogressiveness in native agriculture, and anything done to destroy this attitude and to prove to the native that he has yet much to learn will be of inestimable value in his own interests, and in the interests of the Union of South Africa. Even apart from this aspect, there remains also the fear of being "smelt out" by the witch doctors as unclean. In the old days men thus "smelt out" were killed, together with their wives and children, so that the bad seed might be exterminated. The huts also were burned, and the cattle confiscated by the chief. To this day this very process is carried out in secret. Seldom does information come into the hands of the magistrate. In Tsolo District alone at least two well-authenticated cases are known to me, and I doubt not there are others; and the manner of

* *Op. cit.*, pp. 419-420.

death is so awful that I am not surprised that the natives avoid, as far as they can, even the possibility of an accusation of the kind.

As we shall deal at a later stage with the influence witchcraft has upon the methods of native agriculture, let us leave this aspect for the present, in order to consider these methods as they are employed to-day by the mass of the people; and the first point is the manner of ploughing. Even so simple an instrument as the plough is not properly understood by the red Native, and consequently, instead of ploughing his fields properly, he succeeds only in scratching the surface. The seed is sown by broadcasting, and at one and the same time he sows mealies, Kafir corn, pumpkins, beans, and sugar-cane. The seed is ploughed in, and what escapes the plough is pressed in by hand, or with the aid of the hoe. The harrow is used only in rare cases. The seed is selected with some care, but the selection is not made on scientific lines, nor are they careful to reject the less mature grains at the extremities of the mealie cobs, usually eliminated by the process of "tipping" and "butting."

Year after year the same crops are gathered from the fields without the slightest attempt at rotation, and most of the fields must by now be quite exhausted. In this connection one wonders whether there is no possibility of securing the same result by simultaneous crops carefully chosen as one would by a rotation of crops. Evidently the genius of the small agriculturist and his immediate requirements preclude the adoption of rotation, and if the same, or even approximately the same, result were attainable, it would make a wider appeal to the people than the more scientific course. The present broadcasting method of sowing also tends to a haphazard distribution of the seed both as to position and depth. Consequently, we get one plant interfering with the growth of another by overshadowing it, or by taking the nourishment out of the soil away from its roots, and in other ways.

If the seed were drilled in, there would be a much better result, for the relative distances between the plants would be corrected, and the seed would have a uniform depth; and, in addition, it would make a big difference in the amount of labour necessary in hoeing the ground. The introduction of better methods in this direction alone would make a great difference in the production. For one thing, the crops would stand the drought better, and if rotation were employed, there would be a notable difference in the resistance of disease.

One result of the misfortunes which have befallen the efforts of Native agriculturists in recent years has been the partial elimination of the poor mealies. Where the same mealies are used from year to year for seed, there necessarily is deteriora-

tion of type, and the Natives have for a long time been using their mealies in this way. When the great drought of 1912 came, large quantities of mealies were brought in from other parts of the country, and the introduction of fresh mealies has been continued every season since on account of the unusual series of droughts which have afflicted the country. All this has tended to improve the type of mealies produced by the Native. It will probably come as a surprise to many to hear that to this day it is customary for the heathen Natives to fear lest their fields should be bewitched by some neighbour.

They still go down and burn certain medicines, a collection of grotesque and fanciful odds and ends, in the middle of their fields, in order to prevent their fields being bewitched, or the worm from injuring their mealies, or the birds from eating their Kafir corn. Each man seems to have his own special "medicines," and he relies on these to ensure a good harvest. One may even say that in their view a good harvest is due to the discovery of some effective "medicine" rather than to proper cultivation. But experience speaks in loud tones. Already witchcraft is practised secretly rather than openly, and their belief in its power, while still a force to be reckoned with, may be described as passing.

The growing class of school Kafirs laugh at the old heathen ways, and many of the heathen themselves doubt the efficacy of their sacrifices and medicines. Nevertheless, these are likely to linger for long in the Territories as a superstition at the very least; and at present this must still be classified among the old methods of Native agriculture.

Where land is unlimited in extent, manuring is not very necessary, and until recent years the land was sufficient to support the population, even though no fertilisers were used and the most wasteful methods were employed. But now we have come to the point when an increased production is a necessity, and the supply of available land having come to an end, it is essential for the people to become familiarised with intensive methods of cultivation.

But in other ways, also, the influence of the past has remained with the Natives even to this day. As we have already pointed out, the nomadic life tended to the neglect of agriculture, and the people learned to be content with their herds of cattle and goats, which could easily be driven to safety at the first suspicion of hostility. In fact, the old Kafir custom of ox-racing, which is now practically extinct in the Transkei, was probably due to a desire on the part of the Natives to train their cattle to hurry along at the first approach of danger. Largely as a result, then, of the strife of early times, the Natives became a pastoral people, and even now their instincts remain pastoral rather than agricultural.

4. Enclosure.

Great care is taken to enclose a space for a cattle-fold, but little interest is shown in enclosing their garden land. Of course, the communal system—which dates further back than the tumult which arose less than a century ago—in itself was constructed for, and by, primitive peoples, who did not wish the trouble, if indeed they had the means, of fencing their fields.

Their dwellings were built on a given site, usually on the ridges which were not suitable for garden land, and often amongst the stones or in places not readily accessible.

Their gardens occupied the good land along river banks, in valleys, and even chosen places on the hillside, the gardens of the community being usually grouped together.

Their pasture-land included all the remaining area, where the cattle wandered at will. For mutual self-protection, regulations were framed fining severely the owner of cattle which wandered into anyone else's garden, and the gardens themselves were scrupulously protected from violation.* With this tradition deeply rooted in the Native mind, there has been little tendency to enclose, especially as under communal tenure the land does not become the possession of the individual. He is only given the right to cultivate it.

But the Transkei is now at the transition stage. Several of the districts have already been surveyed, and fields have been given to the Natives on a burdened title. The more backward districts have not yet been surveyed, and these continue under the old communal system. With the completion of this transition we should see a great revolution in land-enclosure, for already one hears from the surveyed districts that the individual ownership is much appreciated, and is working changes in the minds of the people.

Until enclosure has become much more general, we can hardly expect much in the way of accomplishment, and one cannot but hope that Government will make enclosure of the land a condition of tenure. This is by no means an unreasonable or impossible condition, especially as in the surveyed districts endless trouble is being caused by the secret moving, and removal, of the beacons placed by the surveyors to mark out the allotment. If action is long delayed, whole districts may be thrown into chaos, and so cause a most serious and regrettable setback in the transition from communal to individual tenure.

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* I believe the sanctity of the garden land was maintained in large measure on account of the universal fear of witchcraft. It was thought that one man might bewitch another, or bewitch his garden, and if one were found in another's garden, at once the witchcraft cry would be raised, and the culprit would be cruelly done to death. No one wished to meet his death thus, and so each other's gardens were avoided, and even to this day are avoided.

Nevertheless, it is surprising how much land is enclosed by the Natives in spite of communal tenure. Many kraals have an area enclosed by a fence of sorts—sometimes a good strong wire fence with iron standards, sometimes a stone or mud wall, and sometimes the picturesque aloe.

In the census returns for 1911, we find that a total area of 572,107 morgen was then fenced in, and I do not doubt that the next census will show a remarkable improvement on that figure. One fact which surprises the observer is the very large number of small patches carefully enclosed and carefully tended, in which are grown the supply of tobacco for the kraal. Few kraals now-a-days are without the "tobacco patch." But the vast mass of cultivated land is still on the open field system.

5. Irrigation.

Perhaps the unfortunate liaison between "man's work" and "woman's work" accounts in part for the unprogressive condition of Native agriculture.

When the man has ploughed the field his work is finished. The women of his kraal then enter into and complete his labours by hoeing the field at the appropriate intervals.* In normal seasons, at least in some districts, there is no need for anything in the way of irrigation, but the absence of any effort in this direction means that when the drought does come the crop is ruined—and this is the bitter experience which the Transkeian Natives have been having for the last four seasons.

The drought of 1912 is described by the late Chief Magistrate, in his annual report, as the greatest drought since 1862. The people were brought to the verge of famine. Since then three seasons have passed, and all of them yielded but a scanty crop. The people have thus had a very definite lesson, and perhaps where water is abundant there may be a disposition to irrigate. About one-seventeenth of the land now under cultivation is irrigated.

By far the greatest part is irrigated by furrows from constantly flowing streams, but storage dams and wells are not unknown. Already we have about 362,377 yards of furrows, and the extent of land irrigated is 10,215 morgen.

Apart, however, from furrows and streams, we have other sources of water which are sufficient to indicate the supply that is available.

A number of boreholes have been let down to a depth of 150 feet, and these give a supply of pure water, most of which was used for irrigation purposes. Wells and fountains varying in quality to a similar extent, but for the most part supplying

* Broadly speaking, three or four weeks are spent in this work in the spring, and then some two months later; another three or four weeks is spent in the hoeing. The men sometimes help, for their time is now no longer spent in warfare and hunting excursions, as in olden days.

good, pure water, are also in use; and last, but not least, we have storage dams artificially constructed. Some 228 are scattered through the Territories, most of them being constructed of earth and stone.

In the main, however, while it is true that we find some traces of irrigation in the Transkei, yet, on the whole, the Natives have not discovered the value of assisting nature in its beneficent work.

6. Large Farms.

So much has been made of communal tenure that our minds have become accustomed to think of the Natives as peasants rather than farmers on a larger scale. Nevertheless, there are not a few who possess and work farms. In some cases they secured these farms as special grants from Government as a reward for loyalty in the Kaffir wars, but in many cases the more progressive men bought these farms for themselves. In Matatiele district alone 25 farms, of an approximate value of £50,000, are owned by Natives, and in Umzimkulu district we find 50 farms belonging to Natives. It will thus be seen that the Native is capable of working, and does in fact work, farms of some size, that there is already a class of "landed gentry."

In our survey, then, of Native agriculture we must realise that, besides the small peasant-farmer who attempts to produce in the main only sufficient food for the requirements of his own family, we have a substantial class, well distributed through the Territories, of large farmers who can, and do, produce large crops.

Except, however, in the case of a few individuals, we find that the methods of agriculture still belong to the old order of things.

We have already pointed out that the fields are not enclosed, and irrigation is but little practised by the people. The suggestion that the Government should make enclosure a condition of tenure in the surveyed districts, if adopted, would in itself work a revolution. Such a change would be fundamental, and besides making possible the employment of better implements and methods, enclosure would give to the Native a new idea of the ownership of land. These ideas are now very rudimentary, but what a change would result if all the owners of property in the Transkei realised what was involved in ownership—the ideas concerning the values of the land, and of improvements, wastage due to non-improvement, the need for making the most of the limited amount owned*—in a word, revealing to them the duties as well as the rights and privileges of ownership.

* The interpretation to them of the fact that the amount of available land is not unlimited.

7. Agricultural Education.

The reality of the danger caused by an increasing population on a limited area of land has been recognised by the Transkeian General Council, and a notable advance has been made to meet the future. In the first place, large farms were acquired at Tsolo, Mqanduli, and Libode, for experimental purposes, and many thousands of pounds were spent in the equipment and stocking of these places. Reliable experiments are carried out under expert supervision, and above all, the Natives may see for themselves what modern farming means, and acquire the best stock at nominal prices. Already a series of experiments is in hand dealing with cotton as a suitable crop for certain Transkeian districts, and so far the results have proved quite satisfactory. Tobacco, too, is being dealt with, and all manner of questions relating to stock-raising.

More important still is the establishment of an Agricultural College, under Mr. Sidney G. Butler, at Tsolo. It still is in its infancy, and as yet comparatively few Natives have been attracted to it, but the days of small things cannot continue. A sound course of agriculture in all its branches is provided, and the results obtained are astonishing. Courses are provided in agriculture, fruit culture, stock and stock-breeding, elementary economics, elementary entomology and veterinary science, and the students are taught both the theory and the practice of these subjects. The Agricultural College at Tsolo cannot but be of the highest value to the Natives, especially as they come to understand it better, and their sons are attracted to it. But surely every Native Institution in the country should have such training provided as a part of the regular curriculum, and if they have not been thus provided, it has been because of the cast-iron mould applied to the Natives by the Cape Education Department.

The whole educational system has been so moulded to produce Native teachers that at present the rank and file cannot understand the possibility of any other kind of education! Indeed, it is a serious weakness in our system that the Natives are compelled to accept the school standards of the white race rather than allowed to develop along their own national lines. The two races are different by tradition, origin, and circumstance, and instead of each being allowed to develop along its own lines, the one is arbitrarily compelled to follow the standards of the other. In this paper, however, we are not specially interested in the education of the Native except insomuch as it concerns him from an agricultural point of view. If every district in the Transkei had its own Agricultural College, a great contribution would be made—at great expense—towards the introduction of improved methods in agriculture. But a far greater contribution would be made without any additional expense by including agriculture as a subject in the school

curriculum. As a school subject, agriculture is most suitable, especially when we realise the partnership in agriculture between the men and women of the kraal. Apart from an already over-crowded curriculum, the main difficulty in the way of introducing the subject is that the present Native teachers have had no training in agriculture, and therefore the first step would need to be the addition of agriculture to the required subjects for a teacher's certificate.

At first, vacation courses might be arranged and a special certificate provided, so that the present teachers might qualify, but in time the difficulty would be automatically removed.

In due course the school curriculum would be re-arranged so as to include agriculture.

The wisdom of this course is seen when we realise that the older generation is not likely to benefit much by the intensive methods of agriculture. They are almost untouchable. But the children are more susceptible to change, and who can estimate the revolution that will be worked in production when the children leave school after being taught for several years the principles of agriculture—when they leave school and commence to cultivate their own fields. The teaching of 55,000 children would create a new atmosphere and outlook (and anyone who has lived among the Natives will appreciate the need of this change) throughout the length and breadth of the Territories. In its reaction it would produce vastly improved crops, both as to quality and quantity, and these would be available for the needs of the country and for export.

The need for this training is all the greater when we realise that the instincts of the people are primarily pastoral. It is infinitely better for the Union of South Africa, and better for the individual native, to produce a nation of skilled agriculturists rather than to allow that nation to perpetuate a pastoral tradition—to live by the labour of their hands rather than on the strength of the increase of the beasts of the field.

TRANSACTIONS OF SOCIETIES.

CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA.—Saturday, June 26th: Professor G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., President, in the chair.—"*Notes on the treatment of antimonial gold ores from the Murchison Range*": H. R. **Adams.** Metallurgically the ores may be divided into partially weathered surface ores and sulphide ores, each of these again being sub-divided into ores rich in antimony and ores poor in antimony. Methods of treating ores of each of the four classes were described.

Saturday, September 18th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair.—Presidential address: J. E. **Thomas.** The author urged strenuous efforts in the direction of making South Africa more self-supporting in respect of the supplies necessary for the maintenance of the gold mining industry, instancing the local production of zinc and of lead acetate as exemplifying the need and importance of encouraging

the base metals industry in the Union. The possible shortage of gold coinage led, during the early stages of the war, to consideration of the production of gold suitable for making coins of standard fineness; the achievements of the Navy, however, rendered the establishment of the local Mint unnecessary.—"*Cyanide consumption on the Witwatersrand*": H. A. **White.** The annual requirement of sodium cyanide is about 5,000 tons. The possibilities of effecting an appreciable saving upon the cost hereof have recently been considered. Many experiments of various kinds were conducted, details of which were given.—"*The Prevention of hydrolysis in cyanide solutions*": H. M. **Leslie.** Cyanide solutions undergo gradual decomposition with evolution of hydrocyanic acid, even in the presence of excess of alkali. The author quoted details of experiments in proof of this decomposition being due to hydrolysis. The loss to the gold mining industry is estimated to be of the order of £200,000 per annum, and an enormous saving would be effected by the introduction of the "closed" system for the treatment of ores by cyanide.—"*Recent investigations on dust in mine air and the causation of Miner's Phthisis*": Dr. J. **Moir.** The methods in use for laying dust in mine air, when the laying devices are in order and conscientiously used, are as effective for very fine as for coarser particles.

South African Association of Analytical Chemists.—Friday, July 9th: C. F. Juritz, M.A., D.Sc., F.I.C., President, in the chair.—Presidential address: Dr. C. F. **Juritz.** Reference was made to the functions which the Association may reasonably be expected to exercise with respect to chemical science and those who profess it; and also to the relations which should exist between the State and the chemical profession. Attention was drawn to the widely-expressed views regarding the unsatisfactory condition of chemical industry in Britain, and stress was laid on the importance of the chemist in the development of a country's industries. In this connection the potentialities of various chemical industries in South Africa were remarked on, and it was urged that definite steps should be taken to educate the public in regard to the position and functions of the chemist in relation to such industries.

Royal Society of South Africa.—Wednesday, September 15th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*South African Perisporiales*: (1) *Perisporiaceæ*": Dr. Ethel M. **Doidge.** The Perisporiaceæ and allied fungi are very plentiful in South Africa, especially in forest regions and in warm districts with a fairly plentiful rainfall. The specimens in the Union very plentiful in South Africa, especially in forest regions and in warm districts with a fairly plentiful rainfall. The specimens in the Union Mycological Herbarium are mostly from the Woodbush forests in the Zoutpansberg, from the Knysna and from the coast regions of Natal. All that is known of South African Perisporiales up to the present is comprised in diagnoses and descriptions of fungi collected by Professor MacOwan and Dr. J. Medley Wood, and in a few published descriptions of fungi more recently collected. A large part of the Union is totally unexplored so far as this group is concerned.—"*The Arrangement of Successive Convergents in order of accuracy*": Prof. A. **Brown.** One of the most important uses of Simple Continued Fractions is for the solution of the problem to find the fraction whose denominator does not exceed a given integer, which shall most closely approximate to a given number commensurable or incommensurable. The author gives a proof of the rule and a method of arranging the convergents in one set so as to show the nearest in defect, the nearest in excess, and the nearest in absolute value, satisfying the stated condition.—"*The Use of a Standard Parabola for drawing Diagrams of Bending Moment and of Shear in a Beam uniformly loaded*": Prof. A. **Brown.** The important stresses in a uniform continuous beam are the Shear and the Bending Moment; they are best shown in the form of graphs where length along the beam is taken as abscissa and the required function as ordinate.

THE PROBLEMS AND PRINCIPLES OF MALARIA PREVENTION.

By A. J. Orenstein, M.D.

It might be well to summarise briefly the mechanism of malaria transmission from one person to another, so that those of my readers who have not particularly studied the subject may be better able to follow the rationale of the preventive measures which I shall endeavour to outline.

In 1880, Laveran discovered in the blood of malaria patients certain organisms, and came to the conclusion that the disease is caused by these organisms. Acting upon the suggestion of Sir Patrick Manson—the Nestor of tropical medicine—Major (now Sir) Ronald Ross traced the development of a bird parasite, similar to the parasite of malaria, in the *Culex* mosquito, and also partially in the *Anopheles*. Grassi subsequently showed that only *Anopheles* are concerned in the transmission of malaria. Since the days of Laveran's, Ross's, and Grassi's discoveries, a great deal of work has been done in this field, and the present status of our knowledge can be briefly summarised thus:—

Malaria is caused by a protozoan organism, and the three varieties of malaria—quartan, tertian, and sub-tertian (or, as it is otherwise known, æstivo-autumnal or tropical)—are caused by different species of this organism, namely, quartan—the common form of malaria in Italy and other European countries—by the *Plasmodium malariæ*, discovered by Laveran in 1881; tertian, by the *Plasmodium vivax*; and sub-tertian—which is the commonest form in tropical countries—by the *Laverania malariæ*. The last two were first described by Grassi and Filetti in 1889.

It is also not uncommon to see cases infected with more than one of these organisms.

All the parasites causing malaria have one thing in common—they require for their complete development two hosts, namely, the *Anopheles* mosquito and man. When the female *Anopheles* mosquito of certain species (only the females can suck blood) sucks some blood from a man in whose circulation the parasite exists in the sexual form, the parasite, under favourable circumstances, enters upon a cycle of development known as sporogony, which is a sexual process, and when that process of development is completed—which takes about 10 to 12 days—that female *Anopheles* is capable of transmitting the parasite to man.

In the human host a further, asexual, type of development takes place. This is characterised by the following important stages:—

The young parasites injected through the proboscis of the mosquito enter a red blood cell. In this cell they grow until the blood corpuscles containing them are broken up, and the parasites, which have now become subdivided into a number of small young parasites, are thrown into the circulation. Under

favourable circumstances each one of the young parasites again enters a red blood cell, grows, subdivides, and bursts a cell. Thus the cycle is kept up practically indefinitely. Now, the periodical paroxysms of the disease called malaria coincide exactly with the time when a number of parasites rupture the red blood corpuscles containing them and are scattered into the circulation. This freeing of the young parasites is also probably coincident with a release of certain toxins. The parasite causing quartan malaria requires 72 hours for each cycle in the human host. The parasite causing the tertian type requires 48 hours, and the parasite of the sub-tertian type 48 hours or less.

It is possible for one person to be infected with two or all of the three species of the *Plasmodia*, and to be infected with several strains of one species. In either case the periodicity of the paroxysms is, of course, correspondingly modified.

So far as it is known up to the present, only mosquitos of the genus Anophelinæ are capable of transmitting the plasmodium of malaria to man, and it has also been found that certain species of this genus are incapable of transmitting malaria. In fact, up to the present only the following species of Anophelinæ have been demonstrated as being capable of transmitting malaria:—

Anopheles maculipennis Meigen, 1818. Europe and North America.
Anopheles bifurcatus Linnæus, 1758. Europe.
Anopheles pseudopunctipennis Darling, 1910. Panama.
Anopheles tarsimaculata Darling, 1910. Panama.
Anopheles (?) *formosaensis* Tsuzuki, 1902. Formosa.
Cellia albimana Wiedemann, 1821. West Indies and South America.
Cellia argyrotarsis Robineau-Desvoidy, 1827. America.
Cellia pharoensis Theobald, 1901. Africa.
Myzomyia listoni Liston, 1901. India.
Myzomyia funesta Giles, 1900. West Africa.
Myzomyia hispaniola Theobald, 1903. Spain and North Africa.
Myzomyia turkhudi Liston, 1901. India.
Myzorhynchus barbirostris Van der Wulp. Asia.
Myzorhynchus sinensis Wiedemann, 1828. Asia.
Myzorhynchus umbrosus Theobald, 1903. Malay States.
Nyssorhynchus annulipes Walker, 1850. Australasia.
Nyssorhynchus fuliginosus Giles, 1900. Asia.
Nyssorhynchus maculipalpis Giles, 1902. Africa and Asia.
Nyssorhynchus stephensi Liston, 1901. India.
Nyssorhynchus theobaldi Giles, 1901. India.
Nyssorhynchus willmori James, 1904. Asia.
Pyretophorus costalis Loew, 1866. West Africa.
Pyretophorus superpictus Grassi, 1900. Europe, Africa, and Asia.
Pyretophorus chaudoyei Theobald, 1903. Africa.
Pyretophorus myzomyifacies Theobald, 1907. Algiers.

But even where the species of Anophelinæ demonstrated as being capable of transmitting malaria are present, it does not necessarily follow that malaria exists in the locality, for it is necessary that human malaria carriers be also present. For example, in England three species of Anophelinæ are present—*A. maculipennis, A. bifurcatus,* and *A. nigripes.* The first two are known positively as carriers of malaria, and yet England is practically free from the disease.

It is known that both a certain number of human carriers

and a certain number of *Anopheles* of the species capable of transmitting malaria may exist in a locality, and yet the disease be very infrequent. This is a fact of great practical importance to remember in an anti-malaria campaign. One need not necessarily exterminate all Anophelinæ or free from parasites all human carriers, both probably practical improbabilities; it is sufficient to reduce both to what has been aptly designated by Carter as "the non-infective minimum," and maintain them at that level, and for practical purposes the campaign is won.

One more point in connection with the mechanism of malaria transmission before I proceed to the principles of prevention, and this is one frequently missed even by medical men: It is not the man in the acute stage of malaria that is dangerous to the community; he does not as a rule harbour parasites in that stage of their development wherein, if sucked up by an *Anopheles* capable of transmitting the disease, they are capable of going on to development within the mosquito. It is the man who is apparently well that harbours the sexual form of the organism—the only form in which it can proceed to full development within the mosquito. Successive attacks of malaria tend to produce in the infected individual a progressively increasing immunity to the disease, so that in a community where malaria is endemic, a large number of individuals harbour the parasites of malaria in its sexual form without showing any symptoms of disease. For example, in 1905 a considerable number of native children in the schools of Panama were examined, and over 30 per cent. were found harbouring malaria parasites, and yet none of these were ill. In Daressalam in the years 1912-13 over 19,000 adults were examined, none of whom showed any symptoms of disease, and yet 20 per cent. of these were infected with malaria. In 1913 I examined 100 adults and 50 children in Daressalam, taking them at random from the street, all apparantly healthy, and yet of the adults 32 per cent., and of the children 50 per cent., harboured parasites of malaria. Similar observations were made in many parts of the world.

Bearing in mind the facts in connection with the transmission of malaria which I have partially outlined, it becomes apparent that malaria prevention can be carried out along five lines:—

(1) The elimination of human carriers only;
(2) The reduction to a non-infective minimum of the number of Anophelinæ of the species capable of transmitting malaria;
(3) The protection of the individual against the bites of mosquitos;
(4) The protection of the individual by proper medication against the development of the parasite within his blood; and, finally—
(5) A combination of several or all of these methods.

(1) *The Elimination of Human Carriers.*—An attempt to reduce malaria along the lines of eliminating human carriers only is fraught with almost insurmountable difficulties. It means the systematic blood examination of all the members of a community and intensive treatment of persons found affected. The renowned Robert Koch and his pupil and associate, Ollwig, were

great believers in the possibilities of this method, and it was tried out on a huge scale in Daressalam, in German East Africa, between the years 1904-13. The results were far from encouraging, even in that comparatively small community.

(2) *The Reduction to a Non-infective Minimum of the Number of Anophelinæ of the Species capable of Transmitting Malaria.*—This is the plan which has been pursued, with what success most of us know, in Khartoum, Ismailia, and Panama, and is the plan now generally acknowledged to be the most promising of results. I shall therefore go into a little detail as to the technique involved.

In order to insure to a reasonable degree the success of this plan, it is necessary to make a careful preliminary study. The points to be determined are:—

(*a*) The incidence rate of malaria in the locality.
(*b*) The species of Anophelinæ prevalent in the locality.
(*c*) Which of these species are capable of transmitting malaria.
(*d*) What are the life cycle and breeding habits of these species.
(*e*) What are the probable flight ranges of these species under the existing climatic conditions.

In connection with the last, and to show the importance of such a study, I might mention that we were very much surprised in Panama to discover that the malaria-transmitting *Anopheles* prevalent there travelled more readily against the wind, provided its velocity did not exceed about five miles per hour, than with the wind, as is generally assumed to be the case. The discovery resulted in the saving of considerable amount of money in the drainage and treatment of certain areas. We actually were able to leave untreated considerable areas to the windward of certain villages without in any way influencing the malaria rates of these villages.

Having obtained the data outlined above, it should be possible for a competent man to prepare a map on which mosquito-breeding areas of the territory in which the dangerous species of Anophelinæ breed would be shown, and to prepare a scheme for effectively treating these areas, together with a reasonably correct estimate of the costs involved.

Anopheles-breeding areas vary from flowing streams to marshes the consistency of porridge. Some species breed in fresh water only, and the larvæ die out with an apparently insignificant admixture of sewage or salt water. Other species will breed in water considerably contaminated with sewage, and in almost pure sea water. Some species breed in small collections of water such as one finds in roof gutters, hollow trees, at the junction of the leaves with stems of such plants as the banana, etc. Each one of these breeding places must be treated in the manner appropriate to the case and consistent with the economical claims of the community, such as the reasonable claims of the agriculturists, the household owners, the gardeners, the power plant owners, potable water reservoirs, the cattle owners, who may object to their watering places being contaminated with

chemicals, etc. All these points must be given due consideration, and the campaign must be so planned as to secure the maximum of effect at the minimum of inconvenience to the population and damage to property, and at a cost consistent with the resources of the people and with the improvement in health, as well as probable increase in land and property values, which may reasonably be anticipated. Filling, various drainage schemes, deforestation, grass cutting, training of stream banks, oiling and treatment with chemicals, all have their proper uses, and all must be considered.

(3) *The Protection of the Individual against Mosquito Bites.*—Under this head come—

(*a*) The efficient screening of dwellings.
(*b*) The catching of mosquitos within dwellings
(*c*) The use of mosquito nets over beds.

The effectiveness of these measures depends upon the principle that most bites by infective mosquitos occur at night. The value of these protective measures is in the order I have stated them, but one cannot hope to effectively protect a fixed population by the adoption of either or all of these. At best, they are merely measures of amelioration, and their fields of usefulness are temporary habitations, such as camps, military or civilian, isolated farms and individual households in a community non-progressive enough to delay undertaking public measures for its protection against malaria.

A few words in connection with the use of mosquito nets and the screening of houses. I have seen, times without number, nets hung over beds in such a manner that instead of being a protection to the sleepers, they were a menace. It is not sufficient to merely drop the net over the bed, on the outside of the frame. The net must be tucked in carefully all around under the mattress *inside* of the bed frame, and the net must be absolutely free from even the smallest of tears. It is a fact that mosquitos will enter through a very small aperture in search of food, but do not seem to be able to find their way out again. On this fact rests the principle of most mosquito traps. The bed must be reasonably wide, so that the sleeper would not be fairly certain to lie close to the net and be bitten through it. One must make sure also, before tucking in the net, that there are not mosquitos within it.

To make a house mosquito-proof requires very careful planning and a good deal of special knowledge. Most houses that are supposed to be mosquito-proof are merely mosquito traps. A few essential points are:—

The mosquito gauze must have sufficiently small meshes to prevent mosquitos from crawling through; 256 to 324 to the square inch are usually required, or what are known as 16- and 18-mesh gauze respectively. The exact size depends on the prevalent species of mosquitos. By choosing gauze made of pure copper or bronze, and thus securing the maximum of open

space without unduly weakening the fabric, the air space will not be reduced more than about 35 per cent, and that does not matter much even in a tropical climate, provided the ventilation spaces are properly designated and the gauze is kept reasonably clean by brushing.

The window screens must be fixed, not of the sliding variety. Experience has shown that sliding screens are seldom kept shut and in a mosquito-proof condition.

It is advisable to screen the verandahs, and not the windows only. Verandah screens do not deteriorate as rapidly as window screens, and are thus, in the long run, cheaper. Screened verandahs also insure greater protection to the household by providing it with a mosquito-proof lounging space for the hot season, and the ventilation of the house is not nearly so much interfered with as when windows only are screened.

The house must be carefully examined for openings in the floor, ceiling, ventilators, around chimneys, etc., and all these must be made mosquito-proof. In one-storey houses with straight, short chimneys from fire-places, these should be made mosquito proof by inserting well-fitting panels when the fire-places art not in use.

All outer doors must be made to open outwards, must have efficient self-closing devices, and must make a mosquito-proof joint with the frame.

Screened vestibules, or what are generally called "double doors," are necessary only in localities where mosquitos are very abundant.

Mosquito catching, by means of suitable traps or with the aid of slappers, chloroform tubes, and similar devices, is a very useful measure if systematically carried out. It should be done twice daily—early in the morning and just after sunset.

(4) *The Protection of the Individual by Medication.*—Quinine, when taken regularly in proper doses, is a fairly effective measure of prophylaxis. It has been applied with success in the malarious part of Italy. Its exact value in eradicating malaria in a fairly large territory is still a debatable matter, but it is unquestionably valuable to the hunter, prospector, troops campaigning in malarious districts—in other words, to persons compelled to spend some time in a malarious locality. Quinine should be augmented by the use of mosquito nets, screened tents or houses, and a systematic search and destruction of mosquitos within the tents or other dwellings.

(5) *A Combination of Several or all the Methods Enumerated.*—In extending the work of malaria prevention over a considerable area, it is usually found advisable not to rely entirely on one line of effort. The exact combination used depends, of course, on local conditions. Whatever plan is adopted, it is always essential in an anti-malaria campaign covering a large population to secure the co-operation of the public by an intelligent, enthusiastic, and sustained campaign of education. Public

lectures, the co-operation of school teachers, ministers of religion, chambers of commerce and professional societies must be secured, and their interest kept up. This is a most important matter, if for no other reason than because only in that way can the necessary legislation and public funds be secured in a democratic community.

I want to close with a word of advice to any community contemplating an anti-malaria campaign.

Malaria prevention is a highly specialised field of sanitation. In order to secure the best results at the lowest cost, it is essential that the planning and direction of the campaign be entrusted to a competent man. Any man can build a bridge of sorts—it takes a good engineer to build a bridge that will be safe, and yet not cost an excessive amount of money. Malaria prevention on a large scale is a costly undertaking. It may involve large engineering operations, possibly litigation, and a good deal of opposition. It would be a great mistake to entrust such work to a man who merely knows a few of the elements, and has not had the requisite professional and practical training. Such a man would more than likely spend an unreasonably large sum in securing results, even if he did at all succeed in appreciably reducing the incidence of malaria.

SIR HENRY ROSCOE.—The death of the Right Hon. Sir Henry Enfield Roscoe, LL.D., D.C.L., F.R.S., on the 18th December, 1915, at the age of 82, removes from the ranks of contemporary men of science one who has justly been called a great Victorian. Within a few days of each other Meldola and Roscoe have suddenly passed away, the two men who had so persistently and so vainly urged on the British Government and the British public the extreme undesirability of resting upon extraneous sources for dyeing materials and fine chemicals. Like Lord Roberts, they had lived just long enough to see their warnings abundantly justified. Roscoe's first chemistry teacher was Balmain, the discoverer of boron nitride and inventor of luminous paint. After studying chemistry at University College, London, under Williamson, he went to Heidelberg University, and became a pupil of Bunsen. Roscoe began his thirty years' association with Owens College, Manchester, in 1857, when he accepted the appointment of Professor of Chemistry there. It was there that he became associated with Schorlemmer, and together they published their classical "Treatise on Chemistry" in six volumes. When the Society of Chemical Industry was started in 1881, Roscoe became its first President; in the following year he was President of the Chemical Society, and in 1887 President of the British Association. He was Vice-Chancellor of London University from 1896 to 1902, and represented South Manchester in Parliament from 1885 to 1895.

SARCOSPORIDIA.

By Gilles van de Wall de Kock, M.R.C.V.S.

Introduction.

Since the middle of 1914, the Sarcosporidia have come to be regarded by the veterinarians in South Africa as the most important group of organisms that may be responsible for disease amongst some of the domestic animals. That this is the case will be comprehended when the results of the recent researches of Professor Hedinger into the disease *lamziekte* amongst cattle in South Africa are considered. The Professor holds that the cause of the lesions in the muscular and nervous systems of the cattle that have died of *lamziekte* is considered to be due to the action of the toxin and the presence of parasites in the muscular fibres, which parasites belong to the group of he Sarcosporidia. He thinks that the presence of these Sarcosporidia explain the pathology, clinical symptoms, and epizoology of the disease. Can Sarcosporidia be the cause of undoubtedly the most troublesome and perhaps the least understood of all South African diseases? Can it be true that these parasites are responsible for the detrimental effects and financial depression in some of the best stock-raising and cattle-rearing districts?

Moreover, McGowan, of the Royal College of Physicians' Laboratory, Edinburgh, in his investigations into the disease amongst sheep called *scrapie*, makes special reference to its association with sarcosporidiosis. This disease has of late years become widely known in some of the border counties of Scotland, and has only within the last few years, owing, possibly, to its ravages and the consequent effects on the value of the breeding stock, been more openly discussed.

Of great interest is the fact that both Hedinger and McGowan, working on two different diseases (one affecting cattle, the other sheep; one occurring in South Africa, the other in Scotland), arrived at more or less the same conclusions. What raises further interest in this order is the fact that, although Sarcosporidia are very common parasites of domestic animals, yet our knowledge of their structure and life history is in a very confused and incomplete state.

Classification.

Sarcosporidia are protozoon organisms, and have been generally given a place in the class Sporozoa. However, the phylogeny of the Protozoa is still a matter of speculation, and to a large extent of personal opinion, rather than direct observation. Even the class Protozoa in light of recent researches ceases to be amenable to strict verbal definition, and it is not surprising that the limits assigned to it have varied at different times, and are now even debated (Minchin). The modern tendency is rather to split up the vast assemblage into smaller groups, and to abolish the Sporozoa as a primary subdivision.

The class has, however, been retained in deference of custom and convenience. Other points relating to the further grouping of the Sarcosporidia in the class Sporozoa will be considered further on.

Blanchard proposed to divide the Sarcosporidia into two families, as to whether they are found in the muscles (*Miescheria*) or in the connective tissues (*Balbiana*). These two families were recognised as comprising three genera, which were differentiated by the thickness of the enveloping membrane or cuticle of the parasite. The genus *Miescheria* included the intramuscular species surrounded by a thin membrane, and the genus *Sarcocystis* the intramuscular species which had a thick capsule, penetrated by fine canaliculi. The genus *Balbiana* comprised the parasites found in the connective tissues, and these had a thin cuticle. These so-called genera are, however, merely stages in the life history of the same parasite.* Moreover, there is no ground for separating the order into *Balbiana* and *Miescheria* depending on their presence in the muscle fibre, or in the intramuscular connective tissue respectively, since they only represent different forms of growth of the sarcocyst.† In old infectious the parasite may have destroyed the muscle fibre completely, so that the *Miescheria* tubes lie in the connective tissue (*Miescheria*). To avoid further discussion here on the classification, the Sarcosporidia will be considered an order of the Sporozoa, the order being represented by a single genus *Sarcocystis* with several species. The following are some of the principal species that have been recognised by some of the investigators:—

(*a*) *Sarcocystis muris*, found in mice and rats.

(*b*) *Sarcocystis miescheria*, a parasite of pigs.

(*c*) Sarcocystis tenella, a common parasite of sheep and goats. This parasite has been found in man. Probably this species also occurs in cattle.

(*d*) *Sarcocystis immites*, found by Kartulis in multiple abscesses of the liver and muscles of a Sudanese.

(*e*) *Balbiana mucose*, found by Blanchard in the kangaroo, and in the connective tissue of a Sudanese.

(*f*) *Sarcocystis blanchardi*, a parasite of European and Javanese buffaloes.

(*g*) *Sarcocytis gazellæ*, found by Balfour (1912) in the striped muscle of a *Gazella rufifrons*, etc.

However, in light of recent researches by Van Betegh and Doreich (1912), the creation of these different species may not be justifiable, for their researches tend to show that possibly the same species of *Sarcocystis* may occur in a number of different species of animals, and indifferently in birds and mammals.

Hosts of the Sarcosporidia.

In 1843 Miescher discovered in the muscle fibres of the house mouse a peculiar form of parasite, the aggregation of which, in tubular form, were visible to the naked eye. These

* Laveran and Mesnil.

† Bertram and Van Ratz.

for want of more exact nomenclature became known as Miescher's tubes. Herbst afterwards found them in the muscle fibres of the pig (1851). Van Hessling, who in 1846, had observed them in the breast muscle of a roebuck, discovered them also in the myocardium of the ox, calf and sheep; and Rainey, in 1857, saw them in the muscles of a pig. Since then similar organisms, mostly of microscopic dimensions, have been observed in most of the higher vertebrates, especially the mammals, *e.g.*, swine, sheep, cattle, goats, mice, rats, monkeys, buck, deer, camel, dog, cat, rabbit, kangaroo, horses, etc.; Sarcosporidia have been found in man by Baraban and Saint Rainey in the vocal cords of an executed criminal, and on another occasion by Hoche in the muscles of a person who had died of tuberculosis. Kartulis found a sarcosporidium in the liver and muscles of a Soudanese. The parasites found by Hadden, Klebs, Koch and Eve in the kidney, and by Rosenberg in the muscle of the mitrale valve of a woman, are considered (by some) to be the other instances of sarcosporidiosis in man. Vuillimin thinks that systematic investigation would show Sarcosporidia to be a much more common parasite in man than is generally believed. A sarcosporidium which is parasitic to elks and deer is also said to be capable of infecting man.* No Sarcosporidia are known to be parasitic in the invertebrate hosts of any kind.

Occurrence in the Host.

In their hosts the Sarcosporidia are tissue parasites occurring principally in the striated muscles, but occasionally in the unstriated. In a few cases they are found in the connective tissues, but this appears to be a secondary condition, in which the parasite living in the muscle fibres becomes free from them at a later period. In cattle Professor Hedinger nearly always found these Sarcosporidia exclusively in the muscle fibres, and very seldom in the intramuscular connective tissue. In most of the animals that died of *lamziekte* the Meischer's tubes were present in nearly all muscles, regularly in the heart and tongue. In sheep and pigs Sarcosporidia have been found in great numbers in the muscular layer of the œsophagus, and secondarily at the base of the tongue, muscles of the pharynx, cheeks, neck, abdomen, thorax and other skeleton muscles; cysts were also being seen beneath the pleura and peritoneum. According to the above investigators, Sarcosporidia have also been met with in other tissues than the sarcous tissue, *viz.*, liver, kidney.

Spores of the Sarcosporidia have often been encountered in blood smears, sometimes in great numbers, ever since the examination of blood diseases was commenced at the Laboratory, Pretoria.

Cow No. 2,403, that died of poverty at Armoedsvlakte,

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* Brooks.

showed two spores in the spleen smear. In muscle blood smears from 100 carcases (cattle and sheep that died at Armoedsvlakte) 40 per cent. showed either sarcocysts or sporozoites, or both.

McGowan states that nothing of the nature of a sarcocyst, spore, or a possible derivative from such was ever seen in the blood of sheep suffering from *scrapie*.

Morphology.

As a rule the Sarcosporidia appear to be harmless parasites which do not make their presence known by any symptoms of disease, and can only be detected by post-mortem examination, and often only by histological examination. The sarcocysts may present themselves as opaque whitish bodies, usually elongated and cylindrical in form, their long axis running with the long axis of the muscle, encysted in the infected animal, and known commonly as Meischer's tubes. They may be distinctly visible to the naked eye, and often very large. Sarcocysts in sheep reach a length of 16 m.m., while in the roebuck cysts of 50 m.m. in length are recorded. According to some the cysts are yellowish-white in colour, and may vary in size from a millet seed to a hazel nut, with a pus-like contents. Sarcocysts of the mouse, according to Blanchard, is only in the mature state visible to the naked eye, when it appears as whitish streaks running parallel to the fibres of the voluntary muscles. When teased out of the fresh tissue, these streaks resolve themselves into opaque, thin-walled tubes, densely packed with crescentic bodies, the so-called sporozoites. Balfour in 1912, in the *Gazella rufifrons*, described the Meischer's tubes as possessed of a fairly thick cuticle; they measured on an average 4 m.m. in length, and contained the usual sporozoites lying in a milk-white and cheesy medium, which could be easily smeared on a slide, and contained what looked like minute crystals. The Sarcosporidia encountered in certain cattle that had died of *lamziekte* and in the sheep that had died of poverty at Armoedsvlakte were not recognisable macroscopically; cysts as described above were not seen. The Professor gives the size of the very small tubes as 40-68 μ in length and 10-20 μ in breadth. These figures taliate more or less with those of the sarcocysts seen in the muscies of sheep at Armoedsvlakte. Under a higher power Sarcosporidia appear to be bodies of a complex structure with a granular appearance. The latter is due to vast numbers of crescentic-shaped bodies, the so-called spores, sporozoites, sickles, or Rainey's corpuscles, lying in clumps or bunches contained in small oval chambers. The chambers are separated from one another by partitions, which are contiguous with the envelope, which surrounds the whole organism. The membrane enclosing the tubes is at first a fine, structureless cuticle, but before long it thickens and becomes channelled by numerous fine canaliculi arranged for the most part transversely to the long axis of the parasite, but towards the extremities directed obliquely, and at

the tip lying in the direction of the long axis. According to Fiebieger, the striated membrane is not ectoplasm, but altered muscular tissue. Some hold that this cuticle is transversed by fine pores, which are very minute, and not of such a size as to give one the idea that a body of the size of the sarcosporidial sickle or spore could pass through them.

As the parasite grows it gradually distends and destroys the muscular fibre, in which it is parasitic, until finally it is surrounded merely by the sarcolemma and sarcoplasm, and drops out into the connective tissue. This, then, is the way in which the intramuscular parasite (*Sarcocystis*) becomes the connective tissue parasite (*Balbiana*).

Spores, Sporozoites, or Rainey's Corpuscles.

Very little is known about the life history of the Sarcosporidia, and the exact structure of the spore is still a matter of dispute. Moreover, it is possible that there is more than one kind of spore even in the same species of animal. The lengths of the spores have been given by different investigators from 4-8-10-15 μ and the breadth from 1-2-3-5 μ. Blanchard teased out the cysts of the *Sarcocystis muris*, and found that the sporozoites exhibit peculiar movements when observed in a salt solution in a warm stage, and soon change their form slightly. Motility of the spores seem to be a feature of some species. The spores are very fragile, and can easily be dissociated by keeping them in a moist chamber, or by treating them with very dilute acids or alkalis. Its relative fragility, the action of water on it, etc., appears to indicate that the spore does not represent the form under which the parasite preserves itself in the outer world. Negri, Fiebiger, Van Betgh, Teichman, believe that the so-called spores of the sarcocysts of the mouse, horse and sheep reproduce themselves by fission, and so are not spores in reality. Some believe that several kinds of spores have different functions. Apparently the more complicated spore is propagative in function, serving to infect new hosts, while the simple form, which should perhaps be regarded as a sporoblast, as a simple cell not differentiated as a spore, serves for spreading the infection in the same host. The occurrence of the simple type of spore in the sarcocyst of the mouse would account for the manner in which the parasite overruns its host and is usually lethal to it, while the sarcocyst of the sheep, which appears to produce chiefly propagative spores, is a harmless parasite. According to Laveran and Mesnil, the sporozoites of the sarcocysts found in sheep are sausage-shaped, curved, with one end more pointed than the other. At the pointed end is a striated structure representing a polar capsule, and at the blunt end is a nucleus, while the middle of the body is occupied by coarse, deeply-stained metachromatic grains. With reference to the polar capsule, about which there is a diversity of opinion, Minchin divides the Neosporidia into two sections, known respectively as the Cnidosporidia and the Haplosporidia.

The former are distinguished by the possession in the spore of a peculiar structure termed polar capsule, which is lacking in the Haplosporidia.

Watson also figures a large nucleus near the blunt end of the spore, and places the polar capsule at the pointed end. Negri also describes the sporozoite of certain species as having the nucleus near the blunt end, while the opposite extremity appears hyaline and homogeneous for a certain distance. Van Betegh, again, describes a nucleus at the blunt end of the spore, and one or two centrosomes in the middle. Erdmann, on the other hand, places the nucleus in the middle of the body amongst the metachromatic grains, and describes it as a large dense karyosome lodged in a small vacuole; she does not seem to be decided whether the polar capsule is at the blunt or at the pointed end. Teichman describes a large nucleus at the blunt end, and is doubtful as to the existence of the polar capsules. In addition to the spores having this complicated structure, there appears to be also spores of a much simpler structure.* According to Ross (1910), there are two kinds of spores in the ox—(*a*) a sausage or oval form, (*b*) a more elongated form more pointed at one end. The distribution of the chromatin is the same in both. (*b*) In the more elongated form at the pointed end there is a dense mass of chromatin completely filling in the end, no protoplasm being visible between the chromatin and this edge of the parasite. This structure would correspond with the polar capsule as described by Laveran and Mesnil in the more complex form of sporozoite. At the opposite end is another mass of chromatin, which is not terminal (the nucleus of Laveran). Protoplasm can be clearly seen all round it, and the appearance of the chromatin is quite different to that of the other end; the latter stains deeply and uniformly, the former takes a paler stain, and has more deeply-stained chromatin grains scattered through it. Balfour in 1912, in his description of sporozoites seen in a *Gazella rufifrons*, says that when stained with giemsa the above description serves very well, except that the more elongated spore forms in many instances are distinctly crescentic. Also the presence of vacuoles, sometimes small and duplicate, sometimes single, rather large and central, should be mentioned. In the case of the spores stained by Leishman's method the chromatin of the polar capsule was seen to be distinctly granular. Balfour, however, maintains that very different appearance was presented in vital staining with toluedin blue, as employed in the manner described by him in 1912. This method quickly differentiated two very distinct forms of (parasitic) sporozoites. (*a*) One was stout, markedly more rounded at one end than the other, took on a dark blue colour, especially at its centre, and in nearly all cases exhibited a large vacuole towards the more pointed end. This vacuole, which in some spores was very large, was not terminal, and between it and the sharper end was an area of cytoplasm, some of which stained

* Minchin.

as darkly as the central area of the spore. The cytoplasm at the blunt end tended to be lighter coloured. (*b*) The other form was distinctly of a crescent shape, and in many cases was very definitely crescentic, possessing pointed ends, one of which has, as a rule, a little blunter end than the other. The cytoplasm generally stained a very pale violet colour, in marked contradistinction to the deep blue of the stout spores; at or near the centre were grouped violet-coloured granules. In some instances the granules were found rather shattered in the spore cytoplasm. As regard to size, there does not seem to be much difference.

According to McGowan (1914), if the sporozoites or sickles be emulsified in a 10 per cent. acetic acid solution, deeply tinged with thionin blue, a number of important points can be observed. In the first place it will be seen that a definite capsule surrounds the protoplasm of the sickle. Further, by the above method the unstained hyaline capsule is easily seen by contrast with the stained protoplasm of the parasite. Especially is this so at the sharp end of the sporozoite, where a V-shaped space is left between the rounded end of the protoplasm and the capsule.

Possible Development Stages of the Sarcocyst.

Theobald Smith found that when muscular tissue containing matured sporozoites was fed to mice, no evidence of any invasion of the muscular tissue could be observed until the forty-fifth day, when the smallest parasites were detected. These were fusiform in shape, consisting of a delicate structureless membrane, with hyaline contents. As the parasite grows and elongates, its substance becomes divided into a number of fusiform bodies whose long axes are nearly parallel to that of the mother tube. This primary stage of the fusiform bodies is soon followed by another, seen first in the central part of the tube. Here the parasite becomes broader and more opaque. In about seventy days after feeding the parasites enter the stage of spore and sporozoite formation, the substance of the parasite being made up of relatively large roundish or polyhedral masses of a finely granular appearance. These sporoblasts soon break up into the sporozoites, probably eight from each sporoblast. Negri was able to infect guinea-pigs with the sarcocyst of the mouse by feeding them with infected mouse flesh, and found that in the guinea-pig the parasite appeared with different characters from those which it presents in the mouse. Erdmann infected mice with the sarcocyst occurring in sheep. According to Erdmann, the spore germinates in the intestines of the new host, and the first act of the spore is to liberate a toxin, which causes the adjacent epithelium of the intestines to be thrown off. At the same time Amœbula is set free from the spore, and in virtue of the toxin liberated by the spore, the Amœbula is able to penetrate into the lymph spaces of the submucous coat and establish itself there; simultaneously with the secretion of the toxin the metachromatic grains disappear, and it is suggested that the toxin is contained in these granules.

The liberation of the Amœbula from the spore initiates the first period of development, and is passed in the lymph spaces of the intestine, and lasts some 28 to 30 days. For this reason Sarcosporidia have been classed as belonging to the sub-class Neosporidia of the Sporozoa. Minchin says a typical member of the Neosporidia is a parasite of which the life cycle is initiated by the liberation from the spore of one or more Amœbulæ within the body of the host, in the digestive tract in all known cases. In no case does it remain in the lumen of the digestive tract, but penetrates into the wall of the gut, and in most cases migrates thence into some organ or tissue of the host, where it lives and multiplies actively, being usually at this stage an intracellular parasite.

The second period of development begins with the penetration of the Amœbulæ into the muscle fibre, in which the parasite grows into the Miescher's tube and forms spores. According to Negri, the intramuscular development of the parasite begins by the multiplication of the nuclei to about 12, forming a plasmodium. According to Meischer, the plasmodial stage is very characteristic of the subclass Neosporidia; it represents the principal or adult "trophic" phase of the parasite, and is also the spore-forming phase; and, as the name Neosporidia implies, the production of spores begins, as a rule, when the plasmodium is still young, and continues during its growth. Further, Negri holds that the plasmodium next becomes divided up, in parasites about 30 days old, into separate cells or sporants, which multiply actively by division. This form of the parasite now becomes elongated. This stage is reached at about 48 to 60 days. At this point the parasite may disintegrate, setting free the sprouts, or may develope into a Meischer tube. (*a*) In the first case the sporants wander out and establish themselves in other muscle fibres, when its sporont initiates a fresh development. (*b*) In the second case a membrane is secreted round the body, which forms the striated envelope, prolonged inwards to form the chambers. This body then consists of a peripheral zone of sporants multiplying actively, and a central region in which sporants are differentiated. In the development of the spore, the sporant becomes sausage-shaped and multiplies by division. Finally, the sausage-shaped bodies become spores, and are stated to be at first binucleate—probably one nucleus is that of the Amœbula, the other that of the capsulogenous cell. Fully formed spores are found in the parasites from 80 to 90 days after infection of the host.

Symptomatology.

As a rule the Sarcosporidia appear to be harmless parasites, which do not make their presence known by any symptoms of disease. However, a marked contradiction exists as to the power these parasites possess in producing serious and recognisable diseases. There are comparatively few instances in the literature where symptoms have been observed during life of an animal at *post-mortem* which has its muscles heavily infected

with Sarcosporidia. Jardin says that in spite of the statistics of Sarcosporidia in sheep, it should be difficult to admit the absolute harmlessness of Sarcosporidia, if we call to mind what we know to-day of their evolution in the tissues, and of the elaboration by them of a toxic principle. Their presence can, without doubt, remain for a long time unperceived, although the muscles ought to lose in time their elasticity and normal pliability; but it appears illogical that their appearance in great numbers in the important organs, such as the heart in particular, is incapable of causing death. On the other hand, if the toxin elaborated by the Sarcosporidia, the sarcocystin, does not kill the animal, has it not, as all tonic substances, an unfavourable action on the nutrition? And, asks McGowan, in the œdemas, the emaciation, the cacexia—in all these so often concomitant phenomena, ought the toxin not to be taken into consideration? Moule has found the parasite in 98 per cent. of cachetic sheep, and they were very numerous in proportion as the cachexia was more accentuated. Sometimes there were regularly five, six, or more in a field of a microscope in each preparation. Roloff found very large numbers of the sarcocysts present in the muscles of sheep which had died in an emaciated condition in Germany. Watson in 1909 stated that sarcosporidiosis may be closely associated with, and is probably a frequent sequel to, the disease of horses and cattle known as loco-disease. It may complicate the diagnosis of this disease, and also the dourine, and probably of some others, and retard or prevent recovery from these and similar cachetic conditions.

In 1903 Minchin stated that Sarcosporidia in the pig produced paralysis of the hinder extremities, a skin eruption, general symptoms of sickness, such as thirst, increased body temperature, and dim, streaming eyes. According to Professor Hedinger, Sarcosporidia may be responsible for *lamziekte* in its different phases, and produce—

1. Alterations in the cross-striated muscles.
2. Alterations in the peripheral nerves.
3. A toxic substance, which is specific for the central nervous system.

According to some authors, symptoms of illness are often exhibited in horses. In the sheep and goat difficult respiration was noticed (Dammann and Niederhäusern). In an ox stiff gait was noticed (Brouweir), in a pig paralysis of the hind quarters (Virchow), in a horse hardening of the tongue (Hoflich). Moussu and Coquet saw a hard, diffuse swelling of the head of the horse, similar to that seen in purpure; further, urticaria-like swellings on the side of the body, neck, and under the chest; also a diffuse swelling under the belly and sheath, as well as wooden tongue. All these swellings were firm—of a consistence of cartilage—and situated under the skin. Microscopical examination of an excised node showed the existence of sarcosporidiosis. The taking of food and water was made difficult by the changes caused, and movements were executed painfully and slowly. In another case Lienaux saw similar swellings present, and lameness first in the one leg, then in the

other, and then in several legs; in the extirpated pieces of muscles sarcosporidiosis was found. Watson saw dejection, aimless walking about with slow, short step, swelling of the bones of the skull. Sebrazes, Marchal, and Muratet noticed fibro-sarcomatous swellings in the lower chest, and a considerable hard swelling of the metacarpal bones, with the formation of numerous exostoses; further, progressive anæmia, emaciation leading to cachexia, were noticed. According to McGowan, scrapie would appear to be due to a mass infection with the *Sarcocystis tenella*. *Sarcocystis tenella* may be present in 100 per cent. of sheep; in a large number of sheep this parasite does not increase to any extent, and such sheep show no signs of disease (see McGowan's statistics); but in a certain proportion the parasite overruns the host. When this occurs, then, in his opinion, the animal shows evidence of it by exhibiting the symptoms of scrapie, in whole or in part.

Cultivation of the Parasites.

On this point there seems to be little or no information. Piana left Sarcosporidia isolated from the muscular tissue in sterile capsules with a little sterile water or gelatine prepared with *Fucus crispus,* according to the method of Celli and Fiocca, for the culture of the Amœbæ. The falciform corpuscles decomposed and set at liberty little hyaline globules, which gradually increased in volume and acquired a contractile nucleus. They took Amœboid forms, were motile for several days, then encysted, and underwent a true encapsulation, and entered into a state of latency. He observed these phenomena to take place in a space of 25 to 26 days. In 1912 Balfour took the Meischer's tubes from a gazelle, dipped them into spirit, then flamed and transferred them to culture tubes of Nicolle's blood agar; the cysts were then ruptured, thus seeding the medium with spores. He also made broth cultures in the same way, but was unable to trace any development. Many of the spores seem to be quite unchanged after 44 hours at a temperature of about 33° C. Some become spherical in the broth, and thus obviously degenerate. The only point possibly worthy of note was that in both lots of cultures a number of small hyaline spherical bodies were found, many of which contained a dark motile granule. These bodies did not take on the vital staining, and he could come to no decision regarding them, though perhaps they were very young spores. McGowan made attempts to cultivate the sarcocyst in various media at different temperatures aerobically and anaerobically. Media used were broth, blood broth, ascetic fluid with fresh tissues, 1 per cent. glucose water, 1 per cent. glucose ascetic fluid. In all media, with the exception of those containing glucose, the sporozoites either remained unchanged or degenerate. In 1 per cent. glucose water, keeping it at room temperature for about three hours, one sees that every spore has undergone a change. The evolution that takes place is as follows: A ripe normal sickle or sporozoite shows slight enlargement, and later on a slight bulge

on the concave side of the sickle, which is filled with a material containing no granules, at least until the bulge becomes very large. The bulge gets larger, the nuclear spot becomes indistinguishable, the sickle swells, the granules appear to multiply and get larger, and the protoplasm becomes very vacuolated, and the concavity of the sickle appears in the opposite direction, until finally a rounded form is reached. The cyst then bursts, giving rise to an empty round sheath and a mass of vacuolated material containing a large number of granules. This latter mass disintegrates into free granules and *débris*. These granules, according to McGowan, appear to be the final development of the sickle, which produces new infections.

Sarcocystine.

Pfeiffer found that an aqueous extract of Sarcosporidia, inoculated beneath the skin of a rabbit, led to a fall in temperature, diarrhœa, and ultimately death of the animal. Laveran and Mesnil repeated the above, and proved the existence in the Sarcosporidia of the sheep of a toxin to which they gave the name sarcocystine. They prepared both aqueous and glycerine extracts. The toxin is prepared by enucleating a number of cysts, weighing them, and crushing them in a mortar with sterile sand and a known volume of water and glycerine. Filter the aqueous extract through a porcelain bougie, and the glycerine extract through paper. They, moreover, prepared a highly toxic dry extract. A number of cysts are dried in a desiccator over H_2SO_4 and powdered; the white powder constitutes the extract, and must be stored in small sealed tubes.

The properties of sarcocystine resemble those of certain bacterial toxins and venims. The aqueous extract was found to lose its toxicity rapidly, so that in six days it was already much less toxic than when prepared; the glycerine extract, on the other hand, which is quite as toxic as the aqueous extract, keeps much better, and preserves its toxicity unaltered for about a month. The aqueous extract, moreover, loses its toxin, when heated to 100° C. for five minutes, or at 85° C. for 20 minutes. The glycerine extract is more resistant to the action of heat; after heating to 85° C. for 30 minutes, it will still prove fatal to rabbits if inoculated in large doses. The toxicity of the extract is not diminished by triturating it with rabbits' brain or muscles, so that the toxin is not fixed by these tissues.

Sarcocystine, as far as is known, is very toxic for rabbits, and almost without effect on other animals. Guinea-pigs, rats, mice, and sheep are much less susceptible, as are also frogs and tortoises. A dog, a hen, and a pigeon lost weight after injection. The toxicity in the rabbit half a milligramme of sarcocystine killing one kilogramme of rabbit. However, in the literature very varying accounts are given on the susceptibility of various species of animals to sarcocystine.

Teichman and Braun hold that sarcocystine is thermolabile, filtrable, and soluble in salt solution, and rabbits can be immunised

against it. Bienil and Behrens showed that a solution of normal saline of Sarcosporidia of a llama inoculated into rabbits gave rise to symptoms referable to the nervous system—ascending paralysis, subnormal temperature. There was no diarrhœa.

McGowan, in his investigations, made several observations on the effect of injections into rabbits of extracts of muscles from scrapie sheep. These extracts were found to contain a toxic substance similar to that described above, and derived from the Sarcosporidia present in the muscles. The toxic action of the extract was found experimentally into rabbits to depend on the number of sarcocysts present in the muscle. Corresponding extracts from the muscle of normal sheep (without sarcocysts) had no toxic effect. The action of the toxin was chiefly tested on rabbits.

How are the Sarcosporidia Spread?

Investigators tried to transmit the disease by feeding various animals with sarcosporidial flesh. This was based on a possible analogy of the disease with trichinosis. The first experiments which threw some light on the subject were performed by Theobald Smith in 1901. He succeeded in infecting grey mice by causing them to eat the bodies of some of their fellows which had died of sarcosporidiosia. He judged that he had artificially infected the mice by the fact that the percentage of infected mice was much larger than among the stock mice. He thinks that the method of infection is direct, and that there is no intermediate host, such as biting insects, etc. Koch and Negri confirmed Smith's observations, and the latter found that young mice were much more easily infected than old ones. He further states that the fæces of mice that have eaten sarcosporidial flesh are capable of infecting healthy mice from the fifteenth to the fiftieth day after infection. These fæces remain effective if kept dry for a month, or if heated for 15 minutes at 65° C., but lose it if they are heated at 85° C. to 90° C. for a similar period. Negri fed white rats and guinea-pigs on the mouse sarcosporidium and produced the disease in them. Erdmann produced infection in mice by feeding them on the sarcocyst of the sheep. V. Betegh and Dorich fed two ducks and a fowl on cysts from the œsophagus of a sheep and produced an infection. Kasparek injected a mouse subcutaneously with the contents of a sarcospordial cyst from the œsophagus of the sheep. It died in 24 hours, and on examination of the heart blood, he states that he found bodies resembling sporozoites. Pfeiffer had performed a somewhat similar experiment with a somewhat similar result, and suggested the possibility of a blood-sucking intermediate host. Minchin attributes to Watson the statement that sporozoites are to be found in the circulating blood, and draws attention to the possibility of this indicating the transmission by an intermediate host. As pointed out above, sporozoites have often been seen in the blood smears from cattle in South Africa, yet, accepting Sarcosporidia to be the cause of *lamziekte*, all transfusion experiments have failed to set up the

disease. Professor Hedinger, in his report, states that the clinical investigations point to a connection between grass and *lamziekte,* and this point can easily be explained by accepting the theory of a sarcosporidiosis; and although the biology of the sarcosporid is not sufficiently known, we can accept that the infection enters the host with the food. The infection can be a direct one from the grass, or can occur through an intermediate host.

Finally, McGowan, in his recent report on scrapie in sheep, brings forward circumstantial evidence which points to the possibility of a congenital infectiousness.

Biological Chemistry.—Almost all the products of vital activity are compounds, or mixtures of compounds, of the element carbon, and, owing to the property possessed in so marked degree by the atoms of that element of combining with each other, the carbon compounds known at the present day number about 150,000. In these days of specialisation it is no matter for astonishment that so numerous a class of chemical compounds should have a branch of chemistry all to themselves, and this branch is known as "organic chemistry," because it is so indissolubly associated with bodies possessing an organised structure. The circle may be drawn even closer, and, when confined to the carbon compounds which are the constituents of living matter, whether vegetable or animal, and which are concerned in vital processes, is called biological or bio-chemistry. Plimmer's "Practical Physiological Chemistry" was specially compiled as a handbook mainly for medical students, and has been employed for practical bio-chemical work in connection with University College, London. With a medical school gradually developing in South Africa the appearance of a considerably expanded edition of this work* will certainly be welcomed, especially as in its new form it would be difficult to find its superior as an English text-book in practical biological chemistry. It treats bio-chemistry not only from the side of animal physiology, but also from the botanical side, and by means of marginal asterisks and different styles of type it indicates which portions of the book are suitable for advanced courses, and which experiments are within the scope of a preliminary course. The practical methods are presented as concisely and as clearly as choice of diction and arrangement of type can set them forth, and the book will assuredly prove of considerable value in all laboratories charged with the study or investigation of different phases of bio-chemistry.

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* R. H. A. Plimmer: "*Practical Organic and Bio-chemistry,*" 10 × 6in. pp. xii, 635. London: Longmans, Green & Co., 1915. 12s. 6d. nett.

THE ECONOMICS OF THE EAST COAST FEVER AS ILLUSTRATED BY THE TRANSKEIAN TERRITORIES.

By Rev. John Robert Lewis Kingon, M.A., F.L.S.

On three outstanding occasions the natives of the Cape Province have suffered great losses of cattle. The first occasion was the extraordinary cattle-killing delusion of the Amaxosa in 1856-57, which took place at the instigation of Umhlakaza—some say that the real instigator was Kreli, and Umhlakaza was only the agent. But, be that as it may, it resulted in the death of many thousands of natives, and an unparalleled redistribution of the native population.

Mr. Chas. Brownlee, the Gaika Commissioner, estimated that 30,000 Kaffirs entered the Colony and obtained work, 20,000 died, and at least 150,000 cattle were killed. He wrote on 27th October, 1857:—

> From the Butterworth Drift to the Thomas River, all the country for 15 miles on either side of the Kei is now uninhabited, with the exception of a kraal here and there, containing a few individuals, who cannot long continue to drag out the miserable existence they now lead. My tour on the Kei was shortened by the failure of provisions, caused by sharing with the people I found by the way.

Dr. G. McCall Theal says:—

> Between the first and last days of 1857 the official returns of British Kaffraria showed that 67,000 had perished or dispersed. . . . The lowest computation fixes the number of those who perished on both sides of the Kei at 25,000; ordinary calculations give double the number. The power of the Kosa tribe was for the time completely broken.

From these two quotations we see what very serious results followed upon the loss of cattle in 1856-57. In these days of rail and motor a similar situation is not possible; but we see how serious is the situation following upon losses of cattle, and how it is modified by the operation of these factors.

The second great occasion was when rinderpest invaded the Territory in 1897. It has been said that 90 per cent. of the cattle perished then,* and it will be remembered that the disease spread well into the Colony. As the effects of the rinderpest are in the main similar to those which we shall consider in connection with the East Coast Fever, there is no need for us to deal with it at any length, except to show that the present experiences of the natives are not the first of the kind; that since then the communications of the Transkei have been considerably improved by rail and road; and finally, when we come to dealing with the probable effects of the present losses of cattle, we shall base part at least of our argument upon the experience of the rinderpest days.

The third great occasion is that with which we are immediately concerned, the East Coast Fever. We shall attempt

* South African Native Races Committee Report, 2. 266.

to give some idea of the magnitude of the losses sustained before we sketch the economic effects in relation to wealth, agriculture, health, education, and government. An outline of the expenses involved in dealing with the disease will be followed by an attempt to look forward.

I. The Magnitude of the Losses.

The magnitude of the losses may be estimated by a consideration of the area affected, and by the numbers of cattle which have actually died as a result of the disease; for it must not be thought that the only loss is that of the value of the lost stock. For the whole system of transport in a Territory to be disorganised involves of necessity delays in the delivery of goods, increased costs in freight, a slower turn over, and other disabilities which, taken together, mean a direct setback to the commerce.

Well, then, to consider the area affected we must realise that 23 Magisterial districts, out of the 27, were involved, for the East Coast Fever found its way into all except Tsomo, Xalanga, Mount Fletcher, and Matatiele Districts on the Northern border of the Territories. In this area there reside a native population of 772,224 persons, many of whom lost cattle belonging to themselves, and all of whom were closely affected by those losses. It will thus be readily seen how the whole population were vitally and personally interested, and the effect of personal losses upon units must be great when considered in the mass of the people in their relation to, and thoughts of, the Government.

Up to the present I have not been able to discover a reliable and comprehensive estimate as to the number of cattle which have died, and therefore I do not propose to venture upon figures which may be proved inaccurate. It is sufficient if we limit ourselves to that which is more sure, and in estimates of the kind one may reasonably expect the official figures, given by the Magistrates concerned, to err on the safe side. The danger of exaggeration is probably reduced to a minimum.

Bizana District reported a loss of 56,000 head of cattle. Flagstaff is said to have suffered to the extent of 35,000 head. Ngqeleni reports

> The terrible loss to the district occasioned by the destruction of cattle from East Coast Fever. The estimated losses as stated probably exceed 40,000 head, which, based upon the high prices of cattle prior to the appearance of the disease, would represent a sum not far short of a *quarter of a million sterling*.

Elliotdale reports:

> Some three years ago the estimated number of horned stock in this district was about 60,000; at the end of the year 1912, owing to the ravages of East Coast Fever, numbers alive might be placed at about 1,800.

The Magistrate of Tsolo contents himself with the report that

Owing to the ravages of the East Coast Fever the district is gradually becoming denuded of cattle.

From information acquired in conversations I believe the loss in this district, in which I work, to be in the neighbourhood of 40,000. If, then, we sum up the loss of these five districts alone, we get the appalling figure of more than 229,000 head of cattle, and if we apply the valuation as made officially for Ngqeleni District, we find that this represents a loss of approximately one and a quarter million pounds sterling.

South Africa has too long suffered for its lack of population, and, moreover, for the want of capital to develop its great resources. Here at one blow the State loses one and a quarter million pounds in *five* districts—and as yet we have taken no thought of the remaining 18 districts, all of which suffered heavily from this scourge.

Unfortunately, so far as I know, no record was kept of the cattle in the Transkei prior to the 1911 census, and so the figures returned of that date represent the numbers of cattle after the East Coast Fever had been at work for three years. The number given in 1911 was 1,111,705 head. The number officially estimated in 1914 amounts to 434,063 head. As the tide has now turned, and the herds are on the increase, we are entitled to believe that this estimate only partially represents the actual loss; but be that as it may, the difference between these totals shows the decrease to be 677,642. Our estimate, then, is quite inadequate, and instead of a million and a quarter, we must write the loss at four million pounds sterling; and if only one in four had offspring, the loss would be increased to not less than five million pounds—lost for all time to the services of the State, and the enjoyment of the humble peasant of the Transkei.

It is a serious aspect of the existing situation that, even where the progress of the disease has been arrested to some extent, there a subacute phase seems to persist, and as a result a very small percentage of the calves outlive the first year. Attention is now being directed to this point by the experts concerned.

Meanwhile we must add to the capital loss the loss of the increase, which is going on from day to day even now, and more than that, the further increase which, in the course of nature, would result.

	Census. 1911.	Estimated.* 1914.
I. Transkei:		
Butterworth	24,678	10,236
Idutywa	35,758	13,800
Nqamakwe	47,396	35,000
Tsomo	21,975	25,303
Willowvale	42,383	8,000
Kentani	37,721	25,314

* Annual Report, Transkeian Territories General Council, 1914.

	Census. 1911.	Estimated.* 1914.
II. Tembuland:		
Elliotdale	16,705	2,500
St. Marks	42,089	32,237
Engcobo	66,686	10,000
Mqanduli	37,219	7,000
Umtata	55,547	8,580
Xalanga	20,932	18,000
III. East Griqualand:		
Matatiele	70,252	33,045
Mount Ayliff	24,181	7,200
Mount Currie	36,980	—
Mount Fletcher	43,177	52,000
Mount Frere	46,019	29,500
Qumbu	38,739	30,000
Tsolo	40,763	8,000
Umzimkulu	45,246	2,500
IV. Pondoland:		
Bizana	51,972	10,000
Flagstaff	34,046	12,000
Libode	36,281	7,500
Lusikisiki	51,850	20,000
Ngqeleni	40,294	7,448
Tabankulu	46,503	17,500
V. St. Johns	18,645	1,400
Totals	1,111,705	434,063

II. Some Economic Effects.

1. *On Wealth.*—The Transkeian natives, as one might expect, have few ideas on the subject of wealth. For them the horizon is bounded by oxen, women, and Kafir beer, and the chiefest of these is oxen! While they are engaging increasingly in agriculture, and with a surprising degree of accomplishment, nevertheless they are more truly a pastoral people. It is still true to say that the native delights in his herds, and watches eagerly for the increase. The aim and object in life seems to be to accumulate cattle, rather than to accumulate money in the form of gold and silver; but in the ultimate analysis we see that cattle, in the mind of the primitive native, takes the place of the banks which we use. We lock our money up in banks; he locks his up in cattle. We look for interest; he looks for increase.

Now, our system of banking is guarded most carefully by Acts of Parliament, and in other ways, for it is realised how profoundly the trade and commerce and welfare of a country would be affected by the failure of one such institution—not

* Annual Report, T.T.G.C., 1914.

to mention the failure of several. Some have said (surely with astonishing ignorance) that the East Coast Fever has been a "blessing in disguise." If it is a blessing for the whole banking system of a territory to be destroyed, then the disguise is really quite effective! We have already seen the magnitude of the capital loss, but there remain yet further considerations. In order that these may emerge more clearly, let us follow out in fuller detail the banking operations of the native. When money is needed for the purchase of goods, or the payment of debt, it is usual to sell one or more head of cattle. Thus is money withdrawn from "the bank." But the mere suspicion of infection was quite enough to bring upon a district sundry rules and regulations, and sometimes counter-rules and counter-regulations. And even before any suspicions at all were aroused, already the district was placed under the general disabilities which arose of necessity when the Territory was infected. Restrictions upon the moving of cattle paralysed the transport system, and those who had healthy cattle to sell were not able to move them to places where they could secure good prices. Consequently owners were frequently compelled to sell their cattle at ridiculous prices, rather than to keep them and run the risk of losing them at a later stage. Thus the East Coast Fever operated in a double way, either to the total destruction, or at least to the great reduction, of the capital. The very currency of the Territory was subjected to the closest scrutiny, and then the chances were against its acceptance. Such a condition of affairs could not but produce a great shock to the whole financial system of the Transkei.

We cannot imagine the condition of a country in which the banks had lost all their reserves of money. In a modern community such a shock to security would amount to a catastrophe; but in primitive society each man seems content to bear his burden, hope for the best, and commence at the beginning again, and that without anything like the feelings of loss that would be experienced in civilised society.

One thing seems clear in the face of these widespread and most serious losses to the Transkeian community, and that is that in the future we should exercise just as great care to ensure the security of the native "bank" as we take to safeguard our own banks. Not for one moment would we tolerate anything which undermines the security of our financial system, and it is a duty which the State owes to itself, and to the individual, to provide adequate safeguards against such serious outbreaks. This is not the first time that the natives have been denuded of cattle; or, to put it another way, this is not the first occasion on which the State has suffered most seriously from an epidemic of cattle disease.

Trade, naturally, suffered seriously. If people have no money they cannot spend, and the disposition to give credit is hardly encouraged by the knowledge that a man has lost all his

cattle. Nor was the absence of money the only disability which affected trade, for, as we have already indicated, the whole transport system was completely disorganised. Restrictions on the movement of cattle, in conjunction with the extraordinary drought of 1912, which caused scarcity of pasturage, and the actual death of cattle due to the scourge, all combined to disorganise transport. And so, just at a time when people had least to spend, the traders were compelled to pay higher freight for their goods, and therefore to charge higher prices. The cost of living rose appreciably.

Thus do we appreciate the serious condition brought about in this way upon the security, the trade, and the transport of the Transkei.

2. *On Agriculture.*—The effect of a broken transport service upon agriculture was no less than its effect upon trade. In the first place, difficulty was experienced in the supply of improved instruments for use in the fields; and in the second place, those who wished to make use of the manure in their kraals for fertilising their fields were unable to carry the manure from the kraal to the field, and in any case the supply was automatically cut off by the dying of the cattle. Another and most serious effect was that in many locations there were few, if any, cattle left to do the ploughing, and owing to the high freights, those which survived could be more profitably employed in transport work. Consequently many fields were left unploughed which in normal years were used to produce food for the community, and in other cases cultivation was only possible by a return to the primitive hoe in the hands of the women of the location. A third method became widely used in certain districts, where white traders and others sent teams of oxen out on hire. It was quite usual to charge 5s. per acre for the use of the oxen, and as a last resort the native was compelled to accept these services or leave his field unploughed. The overseer who was in charge of the oxen naturally wished to do as much ploughing as he could in order to earn as much money as possible, and the result in too many cases was a mere scratching of the ground, a failure in the crops when the drought came—and the native tightened his belt, in a literal sense, and hoped for a better season next year!

It would have been surprising if, in these circumstances, there was a margin left for selling, but the native is often so improvident as to sell in order to secure money for immediate needs, and then, at a later stage, he is compelled to buy back at a higher price the very mealies he had himself sold. Therefore, at the end of all his troubles, and on account of the transport difficulties, he had no market for his crops except the local market, and the inducements there were really very meagre.

3. *On Health.*—The cultivation of fewer fields in itself was sufficient to mean less food; but, to add to the difficulties of the situation, droughts supervened for three successive years (1912

was the greatest drought since 1862, and caused a most serious situation on account of the consequent famine), at a time when the transport arrangements were disorganised, and insects of all kinds were more abundant than usual, working havoc in the few plants which persisted through the drought. A minimum harvest was the net result. In addition, the milk supply of the people was cut off. The native has three staple foods—mealies, Kafir beer, and *amasi*, the last-named being milk partly soured. Not only, then, did the loss of cattle affect the whole domestic milk supply which afforded the protein nourishment of the people, but also the supply of mealies and Kafir corn was much less. The report of the Chief Magistrate for 1912 well illustrates how acute was the situation caused directly by the East Coast Fever in conjunction with the severe drought, and in order to prove that the contents of this paper are not without corroboration from the situation acknowledged in official reports, it has been thought wise to quote Mr. A. H. B. Stanford's words:—*

> East Coast Fever had decimated their herds, and so, the milk supply being in many places cut off, an extra strain was thrown on the mealie pits. Soon these became exhausted, and a call was made upon the shops, whose stocks were inadequate for more than a passing demand. The drought continued, and the pasturage dried up; team after team of oxen was withdrawn by poverty or death; such transport as remained was vexed and impeded by "breaks" on the line, exigencies of dipping, the general cumber of East Coast Fever regulations. Carriage rose to figures ordinarily termed prohibitive, as much as 7s. 6d. per 100 lbs. being charged for a journey of 30 miles; in places money could not secure it. . . As the ploughing season passed without sign of rain, something like a panic seized upon the natives. . . . Traders' stores were thronged with would-be purchasers of grain; mealies sold at as much as 55s. a bag. Where money was wanting or money could not buy, people were reduced to subsistence on roots; elsewhere they abandoned their homes for better supplied localities.

This graphic picture, as set forth in the official report of the Chief Magistrate, may be accepted as at least not an over-statement, and therefore no one will be surprised to learn that the health of the natives suffered much under the ordeal. At no time are their powers of resistance against disease very high, and very naturally these powers were reduced still further. Pneumonia claimed many victims. For the want of an adequate supply of milk many patients, especially the aged and the very young, were overcome and died. It seems, too, that as a result of this shortage the rate of infant mortality was (and still is) very high—and the State cannot afford so great a loss as that of a single native child.

In a territory in which Colonial law is not yet fully established, and the registration of births and deaths is even yet imperfect, it is not possible to give accurate figures illustrating this point, and in this statement one can only appeal to what has been observed in the course of one's movements among the

* Annual Report, 1912, p. 13.

people. Really, no demonstration is required beyond the obvious statement that, as a result of the shortage in the milk supply, the rate of infant mortality has been, and is, abnormally high.

Apart from the marked effect upon disease, we have also to consider the effect upon the morality of the people. One of the greatest safeguards in heathen life against immorality is to be found in their customs relating to cattle. In the first place, a certain number of cattle are usually given to the father of the bride by the prospective bridegroom. It is said that no idea of "sale" enters into the transaction; but, be that as it may, the fact remains that the custom of *ukulobolo* involves a payment of cattle, and as the loss of cattle has been so general, there has been great difficulty in many cases in securing the required number. Until the cattle were paid, the father was unwilling to allow his daughter to go, and the prospective husband, with every desire to oblige, found that he could not obtain the necessary number. As a result, the impatience of the young couples could not stand the restraint, and the morality of the nation suffered.

Again, from another point of view, we find that sins against morality, usually settled by the payment of cattle, remained unsettled because the culprit had lost all his cattle, and this happening in many cases would tend to break down the custom and encourage the bolder spirits to commit sins of the kind.

Another outcome of such a state of affairs was that men who had no cattle with which to pay the fines were compelled to go out and work at the mines and elsewhere in order to earn the money-equivalent of their fine. Thus, in an indirect way, the flow of labour was affected.

Finally, the practice of polygamy has been appreciably curtailed. In Kafirland the number of wives was wont to proclaim the importance of the individual, for it indicated that he must have possessed many beasts in order to buy so many wives. Since the wholesale losses of stock, polygamy has automatically lessened, and probably the incidence of Colonial law in the interval will tend to prevent substantially the re-introduction of the practice when once more the herds increase. In any case the introduction of individual tenure in the surveyed districts tends very definitely to limit polygamy, for even though the Government is at present allotting land to each wife, yet it is clearly stated that after the first allotment none will be given in respect of future polygamous unions. It seems as if polygamy had received its death-blow.

4. *On Education.*—The cultivation of fewer fields not only affected the food supply of the people, and in that way the health of the community, but also in a roundabout way it left its mark upon the education of the people. Fewer fields to cultivate, and less cattle to herd, simply meant less work for the younger generation, and the setting free of the large class of young boys

who usually spend their time herding. Consequently a large number who had been otherwise employed were set free to go to school, and a scrutiny of the school returns shows that the increase in the number of schools, teachers, and scholars has been very considerable.

In taking note of the figures on the next page, it is necessary to remind ourselves that more than one factor is at work, and therefore we cannot claim that all the increase is due to the East Coast Fever.

In my best judgment, however, I believe that the influence of the disease, by killing off large numbers of cattle, set free for school attendance practically the whole of the herd-boy class. When we read of one district alone losing 58,000, and realise how many boys are required to herd that number of cattle, then we may realise how large is the class of herd-boys set free in the twenty-three affected districts.

A comparison of the returns of grants for education made by the General Council in 1906 and 1913 shows an increase of 50 per cent. Probably, if the income of the Transkeian Council had been unlimited, there would have been a larger grant, but at this point we meet another side-current due directly to the fever.

The income of the Council is limited, and as very large sums of money have been spent in combating the disease, by erecting dipping-tanks throughout the country at five-mile intervals, the result was that expenditure in other directions had to be curtailed. Education suffered equally with public works. The curtailment of the expenditure on education followed just when a large number of children had been set free, and so, while on the one hand we were presented with a great opportunity, on the other hand the difficulties of making the best use of that opportunity were increased.

5. *On Government.*—We have already reviewed all the more important effects, and the one which remains is by no means the least in importance. Plautus, in one of his comedies, has a passage not without aptness in this connection. Sagaristio asks another: "How doth the town seem to be fortified?" The answer given is this: "If the inhabitants be well governed and good, I think it will be well fortified." In any country it is essential for the relationship between Government and people to be of the very best. There should be no friction between the representatives of the Government and the people in normal conditions. Unfortunately this ideal, in the nature of things, could hardly be maintained under the pressure caused by the East Coast Fever. On the one hand, we had a Government doing its utmost by rules and regulations to restrict the spread and the activity of the disease, in the interests of the State; on the other hand, we had individual owners, suffering from these restrictions, objecting very much to them, and doing everything in their power to avoid them.

1.—Transkeian Territories Council Areas.

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Schools ..	590		626	621	687	727	761	791
Teachers ..	1066		1084	1118	1274	1393	1499	1577
Average Roll ..	34980		32759	36623	43088	46276	51334	52156
Av. Attendance	28343		24924	29501	35656	38860	42673	43254
Council Grant	£14207 17 1		£13797 5 9	£14258 13 4	£16806 4 6	£18509 7 11	£20161 17 4	£21985 2 10

2.—Non-Council Area.

	1906.	1907.	1908.	1909.	1910	1911.	1912.	1913.
Schools ..	219		225	205	145	101	110	118
Teachers ..	388		352	333	214	144	176	189
Average Roll ..	12419		12088	11048	6898	4632	5835	6306
Av. Attendance	10220		9154	9130	5707	3861	4780	5214

3.—Pondoland.

	1912.	1913.
Schools	65	67
Teachers	75	83
Average Roll ..	2736	2842
Average Attendance	2290	2175
Grants	—	—

Transkeian Increase Alone.

1906.	1913.	Per cent. increase.
809	976	8·27
1454	1849	27·16
47399	61304	29·33
38563	50643	31·32
£14207 17 1	£21985 2 10	54·74

We could hardly expect a primitive people to be patient under these rules and regulations, supplemented by special instructions to Magistrates, and supported by various proclamations and counter-regulations. That they were patient for so long speaks well indeed for all concerned.

Nevertheless, the by-products of all these attempts was a spirit of vexation, and even open discontent. The Magistrate was in the unhappy position of insisting upon regulations which caused real hardship upon individuals, without securing any obvious advantage.

Thus cattle were not to be removed from infected areas, or suspected areas, and still the fever made its appearance in the isolated places! Or, again, the native wishing to move his cattle to some place where he could sell them for a good price, found that certain regulations stood in his way, and so he was compelled to sell at a nominal price to some white trader. Understanding "the ropes," the trader was able to remove those very cattle to that very spot, and sell the cattle at a profit. Such a situation was hard to avoid in framing regulations for a primitive community, and in practice the regulations made possible to the white man what was debarred the native. A fence was made right across the country to keep the infection from spreading, and before it was finished, the infection had already passed at the completed end. Inoculation was resorted to, but unfortunately the virus seemed to kill more than it cured. Finally, dipping was proved to be efficacious, and accordingly an extensive programme of tank-building was carried out all through the Territories. At this point the native loyalty was strained to the utmost, and it is not surprising that the discontent o'erflowed. We live in days so full of great events that our minds speedily forget even important occurrences. The important occurrences to which I refer will be gauged when accounts come to be settled up; already they have been the subject of a special inquiry and special report to Government. It is sufficient for the purposes of this paper to make my point and pass on. The discontent of the people—for the most part, *but not wholly*, passive—must have had no small effect upon the administration of the Territories, demanding, as it did, the military occupation for some months of three disaffected districts.

III. The Expenses Incurred.

It had been my purpose to develop at some length not only the losses to the State in the manner already described, but also the cost to the State of the various attempts which sought to restrict the activities and stamp out the scourge. Unfortunately, much of the information is not yet available, and I have been able to consult only a part of that which is available, and therefore I do not propose to more than indicate the directions of

expenditure. The simple statement in itself will indicate sufficiently the values involved.

(*a*) In the first place, a wire fence was made from the Natal Border to the Western Border, some hundreds of miles in length. We have already indicated that the fever crossed at the completed end before the fence had been carried to the other terminus, and thus perished the first attempt, and with it all the money needed for so great an undertaking.

Even after the infection had crossed over the fence, the police arrangements were carefully maintained, at great expense, on the proverbial stable-door principle.

(*b*) In the second place, it was at one time believed that inoculation was a certain cure for the disease, and a regular campaign of inoculation was organised. But the natives opposed this movement to the utmost, and only yielded with the greatest unwillingness; and the adverse results which followed in not a few cases rendered these difficulties all the greater. A native farmer near to me sent 119 beasts for inoculation, and only six were saved! Occurrences of that kind, for which not a farthing of compensation was forthcoming, certainly did not encourage other natives to agree to the inoculation of their cattle. Of 158,884 cattle inoculated, it is roughly estimated (very roughly, and perhaps too liberally) that the survivors amounted to about 33 per cent. Those that did survive certainly were immune, but the cure was rather too drastic, and the amounts involved in these operations include not only the loss of the cattle, but also the expenses of the veterinary staff, together with the expenses of experiments and the advice of experts.

(*c*) In the third place, dipping-tanks were erected throughout the length and breadth of the country at a five-mile radius. In the latest returns I discover that 181 tanks were in use and 28 under construction, as at 1st January, 1914, and additional to this we have an estimate of £16,193 for construction of tanks in 1913-14, and a rough estimate of £19,600 to be spent in 70 tanks to complete the programme. In the estimates, £280* is allowed per tank. We thus have the cost of 209 tanks, + £16,193 + £19,600, which gives us the total of £94,313.

The capital cost, however, does not exhaust this item, for a charge is levied of ½d. per head for the dipping of the cattle, and while at present there seems to be a deficit in the working, yet in time, no doubt, this will be a source of revenue. It was estimated that the fees should yield some £17,740 in 1914.

It will thus be seen that considerable sums of money are involved in this undertaking, and the economic effects are of no slight importance.

(*d*) Finally, it will be realised that all these expedients would cause some strain upon the police arrangements of the Territories. If the fence was to be made an effective barrier, it

* Some tanks cost twice that amount.

must be made impossible for any parties to break it at any point at any time. As a matter of fact, in spite of precautions, cattle were driven through at various times; at any rate, the opportunities were reduced to a minimum, but only by the ceaseless activity of the S.A.M.R.

Again, the enforcement of inoculation regulations threw some strain upon the police, as also did the establishment of the dipping tanks. In the case of the last item the expense was enormously and unexpectedly increased by certain occurrences at Matatiele, to which reference has already been made. Possibly that expense will be found (when the figures are published) to exceed by far the total cost of the building of all the tanks. But, be that as it may, we have said sufficient to show that the amounts involved form no inconsiderable item, and play no small part in arriving at an estimate of the effect of the East Coast Fever.

IV. Reconstruction.

We have endeavoured, almost at too great length, to trace out the effects of this disease from an economic standpoint. It is, indeed, surprising to follow out the actions and interactions, and to realise how farreaching they are in their effects. One point of considerable importance which has not yet been mentioned is reserved for consideration at this stage of our enquiry, namely, the effect which has been produced upon the supply of labour.

The loss of all these cattle has meant that when the native desired ready cash he had no cattle for sale in order to realise the amount required. Consequently, he has been compelled to go to work, a compulsion which has grown stronger with the successive droughts of recent years, and the question of highest economic interest in all that has happened is this: Will the East Coast Fever be to the natives of South Africa what the Black Death of 1352 was to the people of England? Will it release labour for the agriculture, and the industries, of South Africa, and will it afford new opportunities to the people? These questions no man can answer with certainty. The natives are a peculiar people, and there is no saying what they will, or will not, do. But to begin with, we must remember the radical effects of the cattle-killing of 1857—how the distribution of the people was completely altered. At this period they were living between the Kei and Bashee rivers, but after 1857 the survivors lived, where they had fled in search of food and work, in the Colony almost as far west as Port Elizabeth. This redistribution was accompanied by the loss of almost, if not all, their cattle, together with the loss of all their other possessions. If any revolution was to take place in their outlook and manner of life, surely it would be after such a rude awakening.

Again, in 1890, we had a succession of droughts which

"destroyed* 100,000 cattle," and in 1897 the rinderpest carried off nearly all their cattle, and yet these people have experienced no outstanding change in their manner of life. Possibly there may have resulted great and outstanding changes following the rinderpest had not the war come upon the country, causing the dislocation of everything requiring labour, and while men's minds were filled with other thoughts the opportunity passed. That the results which followed upon these events were not comparable to those attendant upon the Black Death might lead us to expect a repetition in this case of negative results.

The fact is that the Territories cannot be quite the same after this widespread loss of cattle—that some advance has been made by the very shock to the tribal system, and tribal tradition, and tribal customs; but we need hardly look for immediate and revolutionary change. Already the change is stealing over the land quite rapidly enough in some ways, and acceleration may not be altogether an advantage.

The Black Death affected the people in their relation to land and wages. Not the cattle merely, but the population of the country, was reduced by one-half, and more. And so it seems to me that once again the natives will stand their losses bravely. They were accustomed to lose their all in the days before the Transkei was taken over by the British Government; and the stern discipline of those days has not been in vain. And probably the revolution for which we look will come not as the result of this, or that, great loss of cattle, but rather by the economic pressure which will result with the passing of communal tenure. It is well that that passing is being introduced gradually, for the revolution for which we look is already in process, and the day can hardly be far distant when we shall see and feel the travail of those times.

Potash from American Kelp.—F. K. Cameron, in United States Commerce Report 143, referring to the available seaweed beds of the Pacific Coast and the annual kelp harvest, says that the amount of potassium chloride which it is possible to produce is five times the total import of potash salts from Germany, calculated as chloride. The cost of handling, drying, grinding, storing and loading at San Diego and neighbourhood will not far exceed one dollar per ton of dried kelp. Cutting and collecting is estimated at 1 dollar 83 cents, and general expenses at one dollar, making a total of 3 dollars 83 cents. The manurial value of the dried kelp is calculated at 15 dollars 75 cents per ton, nine dollars of which represents the value of the potash.

* Short papers by Andrew Smith, p. 35.

CAN LITHIA BE A CONSTITUENT OF PLANT-FOOD?

By Professor PAUL DANIEL HAHN, M.A., Ph.D.

Since the introduction of water-cultures into biochemical research, it has been ascertained that the number of elements, which are absolutely indispensable constituents of plant-food, is rather small—potassium, calcium, magnesium, iron, sulphur, phosphorus, carbon, nitrogen, oxygen, and hydrogen. In addition to these, a large number of elements have been observed in different plants, of which some are of frequent or, rather, of regular occurrence in the ashes of all land plants and in all parts of the same plant—copper,* zinc,† manganese,‡ aluminium, lithium, sodium, rubidium, cæsium, barium, strontium, lead, nickel, cobalt, silicon, chlorine, sodine, bromine, and fluorine. Of this series of elements, three—chlorine, sodium, and silicon—have been found in the ashes of all higher plants, although it has been definitely proved, by the results of water-cultures and of experiments made in prepared soils, that they are not indispensable for the growth and for the full and complete development of higher plants and of the crops we cultivate. Regarding the physiological functions of these three elements and their compounds in the plants, nothing definite is known.

Of special interest in their relation to plant life is the group of alkali metals: Lithium, sodium, potassium, rubidium, and cæsium. Potassium is the typical element of this group, and we know more of its functions in the system of plants than of the other elements. The rapid and enormous growth of the industry of the potash fertilisers furnishes striking evidence of the practical application of the results of scientific research to agriculture.

In the order of the natural classification of elements potassium has its place between sodium and rubidium. Both these elements occur frequently in plants, although it has been sufficiently demonstrated by the results of water-cultures and soil experiments, that they are not indispensable constituents of the food of land plants. They may enter the system of plants

* The "copperplant" of North Queensland (*Polycarpæa spiriostilis*) contains as much as .56 per mille of copper in the dry plant substance. Prospectors conclude from the occurrence of this plant that cupriferous deposits must be near.

† Zinc has been observed in the ashes of *Viola calaminaria*, growing on the Calamine Hills of the Rhenish Province.

‡ Manganese is a never-failing constituent of the ashes of the *Conifera*. in some of which the amount of trimanganic tetroxide rises to 40 per cent. of the weight of the ashes. A large number of analyses of the ashes of various portions of pines from different parts of the Cape Peninsula were made some years ago in the Chemical Laboratory of the South African College. The results of all these determinations showed that oxide of manganese was the predominant constituent in all these ashes.

in considerable quantity without interfering with the normal growth and development of plants.

The two elements—lithium and cæsium—the lightest and the heaviest of the alkalies, are supposed to possess a destructive action on plant-life. Cæsium has only once been found in vegetable substance; Grandeau observed it in the ashes of beetroot molasses. From the results of water-cultures and soil-experiments, it appears that cæsium compounds act as "a poison on vegetable life."

Lithium compounds are more widely distributed in soils, and are also present in larger quantities in soils than cæsium compounds. Lithium has also been observed in a large number of plants, such as *Carduus, Cirsium, Salvia, Sambucus*, and tobacco. The ashes of Rhodesian tobacco, examined in the Chemical Laboratory of the South African College, were also lithiferous, as could easily be shewn by spectroscopic examination of the ashes of the tobacco. It has been definitely proved that lithium cannot displace potassium, and that it retards and even impedes the growth of many plants, which had been planted or were growing in soils and solutions, in which the potassium compounds had been *completely* displaced by the corresponding lithium compounds.

In order to ascertain whether lithium compounds are taken up by the roots together with potassium compounds, when both kinds of compounds are present in solutions, and whether, under these conditions, the seed of the plants grown contains in addition to the potassium compounds also lithium compounds, some water-culture experiments with wheat were carried out in 1914 and 1915, of which the following is a brief account.

The two kinds of wheat were *Spring Wheat* and *Medeah Wheat*.

The solutions contained, per litre:

1 gramme calcic nitrate.
.25 gramme magnesic sulphate.
.25 gramme potassic nitrate.
.25 gramme ferric phosphate.
.25 gramme hydric potassic phosphate.
.25 gramme lithic nitrate.

Large, two-litre jars were used to give the roots ample space for expansion.

These experiments were started in June, 1914, and for the first three months the solutions were changed weekly; subsequently on greater development fortnightly.

Growth was well maintained till the end of September, when all the plants showed signs of decline, and continued to do so. In November the first signs of ears were seen. These developed apparently in the usual manner. At the end of January all the plants dried up. The "spring" wheat had then attained a

height of 6′ 3″, and the "medeah" wheat 5′ 2″. On the "spring" wheat there were four, and on the "medeah" wheat five ears. The ears of both kinds of wheat were found to be absolutely empty; not a vestige of grain was in the ears. A very large number of water-cultures had been carried out in previous years with normal solutions under the same conditions, and in each case a fair number of ears was formed, and an abundant crop of grains harvested.

From the results of these experiments one cannot help coming to the conclusion that the presence of lithium compounds prevented the formation of seed; and also that the signs of decline of growth, which were noticeable after the end of September, are attributable to the presence of the lithium compound, because in normal solutions vigorous growth is maintained to the end of the period of vegetation.

According to the analyses made of the air-dry plants, the "spring" wheat yielded as much as 14.85 per cent., and 14.03 per cent. of ash, whilst the "medeah" wheat yielded 9.41 per cent. and 9.91 per cent. of ash. These results are higher than the ordinary average percentage of ash in wheat, *viz.*, 6.1 to 7 per cent. The plants had evidently freely absorbed the saline ingredients of the solutions.

The quantity of ash obtained by the incineration of the four plants was only small and insufficient for a gravimetric determination of lithium, the presence of which in the ash could readily be ascertained by spectroscopic examination. But the different degree of brightness of the light of the lithium lines in the comparative spectroscopic tests evidently proved that "medeah" wheat had absorbed a larger proportion of the lithium compound than the "spring" wheat.

These experiments show that lithium compounds in the presence of potassium compounds do not influence the growth of wheat in water-cultures during the first period of vegetation, whereas in the later period the growth of the plants is rather retarded and the formation of grains prevented.

The experiments are being continued with modified water-culture solutions and on prepared soil. They will also be carried out with potatoes planted on soil supplied with an amount of lithium compounds equal to the quantity of potash in that soil.

The subject is not only of biochemical, but also of therapeutical interest, since lithium in starch, obtained from starch-producing plants, would undoubtedly be the most suitable form of introducing lithium into the system of persons suffering from gout.

THE CONSTITUTION OF THE SENATE.

By Frank Flowers, F.R.A.S., F.R.G.S.

At the Kimberley meeting of the South African Association for the Advancement of Science an interesting paper was read by Dr. A. H. Watkins, M.L.A., entitled "A Suggestion Concerning the Constitution of the Senate." I am glad that this paper was subsequently published*, because it is well that any suggested revision of our constitution should be discussed in the absolutely non-party spirit of Dr. Watkins' paper, and of this Association's Proceedings.

The debates in the last session of Parliament clearly indicated the necessity for some revision of the Senate; thus one member of Parliament referred to the "dormant Senate," and the daily press stated that the rapidity of business in that House is limited only by the speed of the Clerk to read the titles of the Bills.

I am thoroughly in agreement with Dr. Watkins' main propositions, which are worth repeating:—

> The main function of an Upper Chamber is to act as a chamber of review, so as to assure all legislative measures receiving careful consideration by an independent authority removed from the controversial atmosphere of the House in which they originate, to check that hasty legislation which is apt from time to time to occur in any country during times of national stress or national excitment, and to give time for its being subjected to the sober "second thought of the nation" (page 253). The Upper Chamber should not possess the power of permanently blocking the deliberate will and wish of the nation, when after calm consideration it is determined to place certain measures on the statute book or to follow a certain line of policy, whether it be social, economical, or financial.†

I cordially agree with Dr. Watkins that under any party system nominated Senators will be party men.

Dr. Watkins' suggestion is that whilst the Lower House should be elected by voters over 21 years of age, the election for the Upper House should be limited to those voters who are over 40 or 45 years of age.

This ingenious suggestion suffers from the defect that the Upper Chamber will "possess the power of permanently blocking the deliberate will and wish of the nation." Dr. Watkins tells us, however, that in such a case, the young voters must wait until they are 40 or 45 years of age, when they will have a chance of putting in other Senators. I suppose the average "wait" would be 15 years, and it seems to be too long a time.

I would rather suggest that the Senate be replaced by the adoption in our constitution of the Referendum Vote. This would ensure that every act of legislation would be certain of receiving "careful consideration by an independent authority," and that it could not be placed upon the Statute Book until it

* Rept. S.A. Assn. for Adv. of Sc., Kimberley (1914), 253-260.
† p. 254.

had been sanctioned by "the deliberate will and wish of the nation," which in substance are Dr. Watkins' two main propositions.

The exact form that the Referendum should take if it is adopted is a matter for discussion. It might be invoked by a popular petition of 5 per cent. of the electors, or of 10 per cent. of the Lower House, and emergency Bills passed by a two-thirds vote might become law temporarily until ratified or vetoed by a Referendum Vote.

It will be remembered that a Referendum Vote was taken in Natal as to whether that Province should join in the Union, and that Referendum Votes are constitutional in Australia, Switzerland, and in many States of Amercia. The universal experience is that Referendum Votes have a conservative leaning.

The Earl of Selborne, in his interesting work "The State and the Citizen," refers to the Referendum as the simplest device ever adopted by democracy, and says that

> the Referendum, therefore, may claim some part of the blessing pronounced by Disraeli upon those who are wise enough to trust the instincts of a people.

MANGANESE IN WHEAT.—The *Journal of Agricultural Research** contains an article on the occurrence of manganese in wheat by W. P. Headden, Chemist of the Colorado Agricultural Experiment Station. In examining the mineral constituents of wheat, the author was struck by the fact that there was uniformly enough manganese present to come down with the calcium oxalate and to impart a decided brown colour to the calcium oxide when ignited. Further investigations followed, leading to the conclusion that manganese is present in wheat wherever grown, irrespective of the conditions of soil and climate. The author also found that the manganese is present in the wheat kernel in about the same proportion as iron, notwithstanding the predominance of iron in the soil, and that fertilisers applied to the soil did not affect the amount of manganese stored in the kernels, nor was this amount affected by variation in the quantity of water applied. The author thinks that facts seem to support the view that manganese is an essential constituent of wheat, and possibly also of rye, oats, and other cereals.

* (1915) **5** [8] 349-355.

NOTES ON THE CHEMISTRY OF THE !NARAS.*
(*ACANTHOSICYOS HORRIDA* HOOK.)

By WILLEM VERSFELD, B.A., D.Sc., and GILBERT FREDERICK BRITTEN, B.A.

(*Plates 2-4*).

Some years ago inquiries were made by the Soudan Government as to the possibility of cultivating the valuable !Naras plant in the deserts of Northern Africa. Experiments were made with seeds procured from Walfish Bay, but apparently without success. It was in connection with these experiments that investigations were made by the writers as to the nature of the plant, and the character of the soils on which it grows.

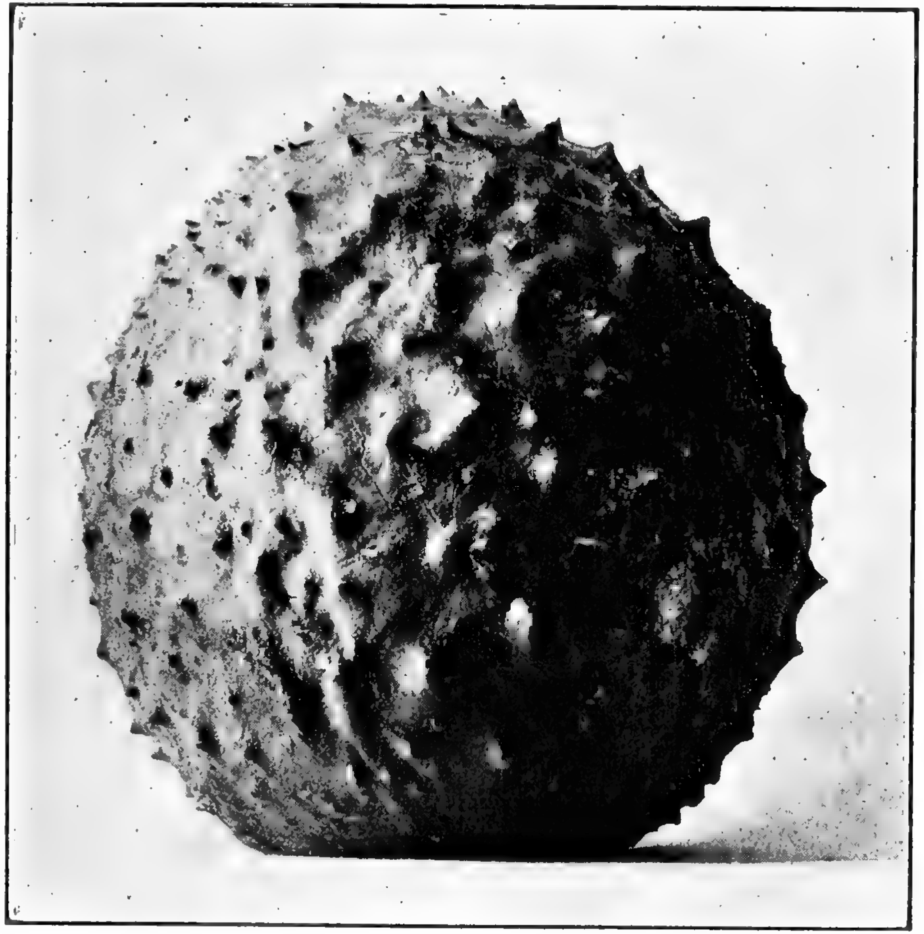
It was, not unnaturally, assumed that, since this plant flourished apparently only under desert conditions, such conditions were necessary for its development, and that the waterless deserts of Northern Africa could also support it. The results of recent investigations have proved that the !Naras plant of Walfish Bay is, after all, not so very wonderful, being very well supplied with both food and water, and that it thrives not because of, but in spite of, the desert conditions. Its only really remarkable property is the ease with which it overcomes the physical difficulties connected with life on a moving sand-dune.

OCCURRENCE AND DISTRIBUTION OF THE PLANT.

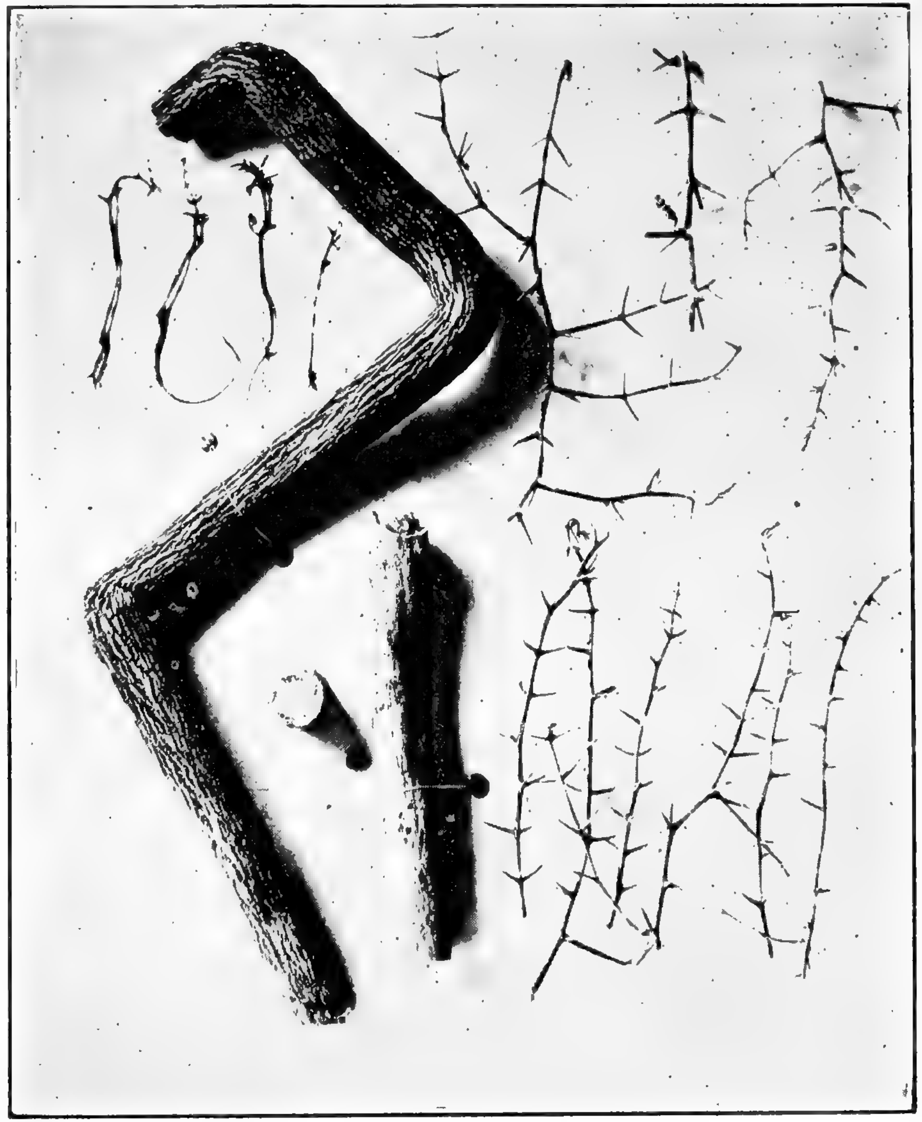
The !Naras plant, which was discovered by the botanist Welwitsch, is found in considerable quantities at Walfish Bay, and in smaller quantities at a few localities on the coast further north in the neighbourhood of Mossamedes. The particular state of development at which this plant has arrived has so obviously been evolved from the unusual combination of circumstances under which it grows that it is unlikely that a similar plant will be found, or even be made to grow, in other places where different conditions obtain. These conditions, as far as we know at present, are a very dry and warm climate, a loose sandy soil produced in the disintegration of rocks rich in plant foods, almost incessant winds and a good supply of deep-seated water.

In the neighbourhood of Walfish Bay, the chief centre from which the plant has spread appears to be at Sandfontein, about four miles east of the bay. From this point it has spread some distance inland, and also to Haigamchab, on the Swakop River, and to Pforte, about 40 miles east of Swakopmund. In the sand-dune region along the coast the plant gives rise to the formation of dunes, the growth providing a barrier for the

* The ! represents a palatal click.

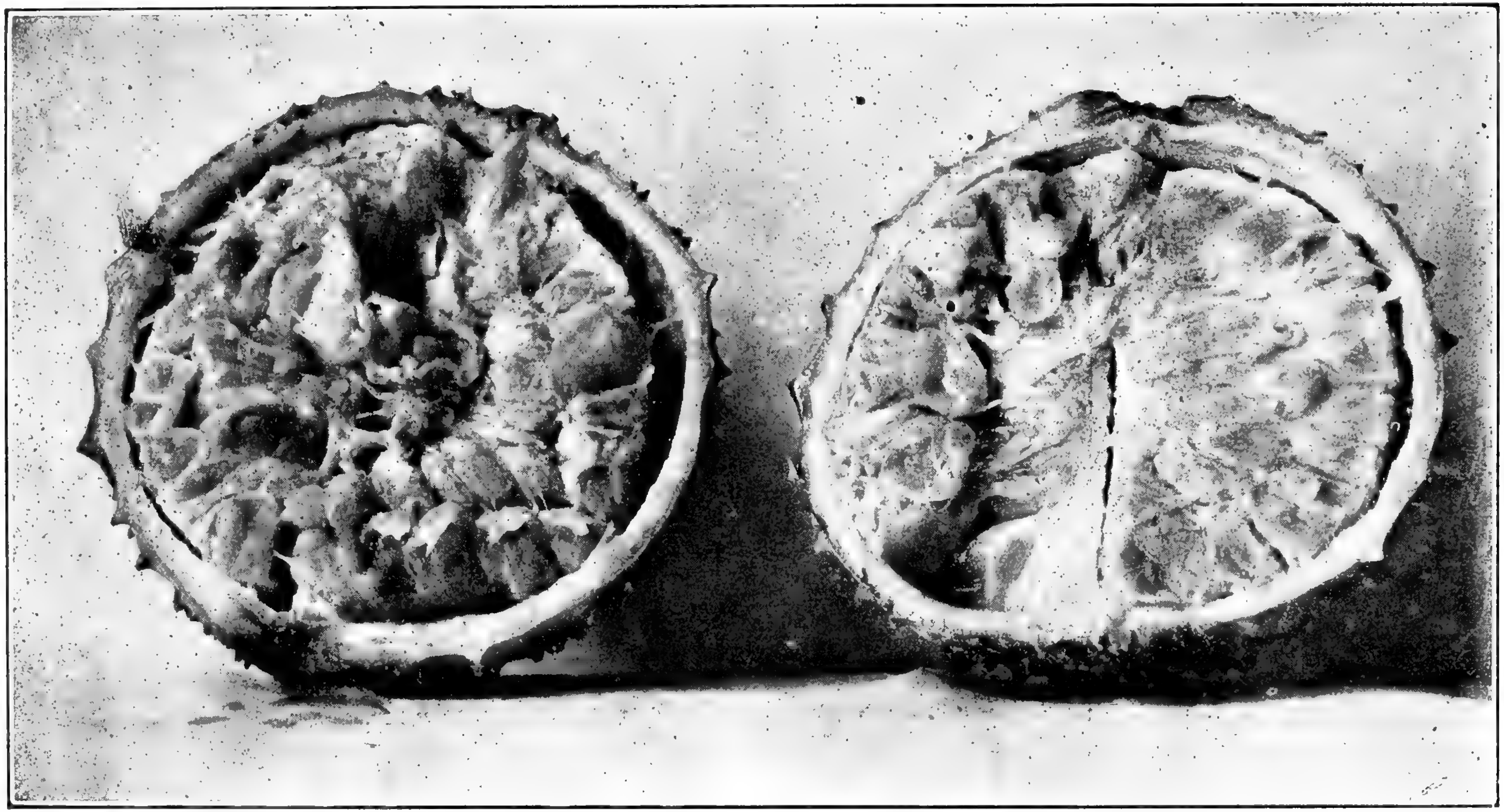


The ! Naras Fruit



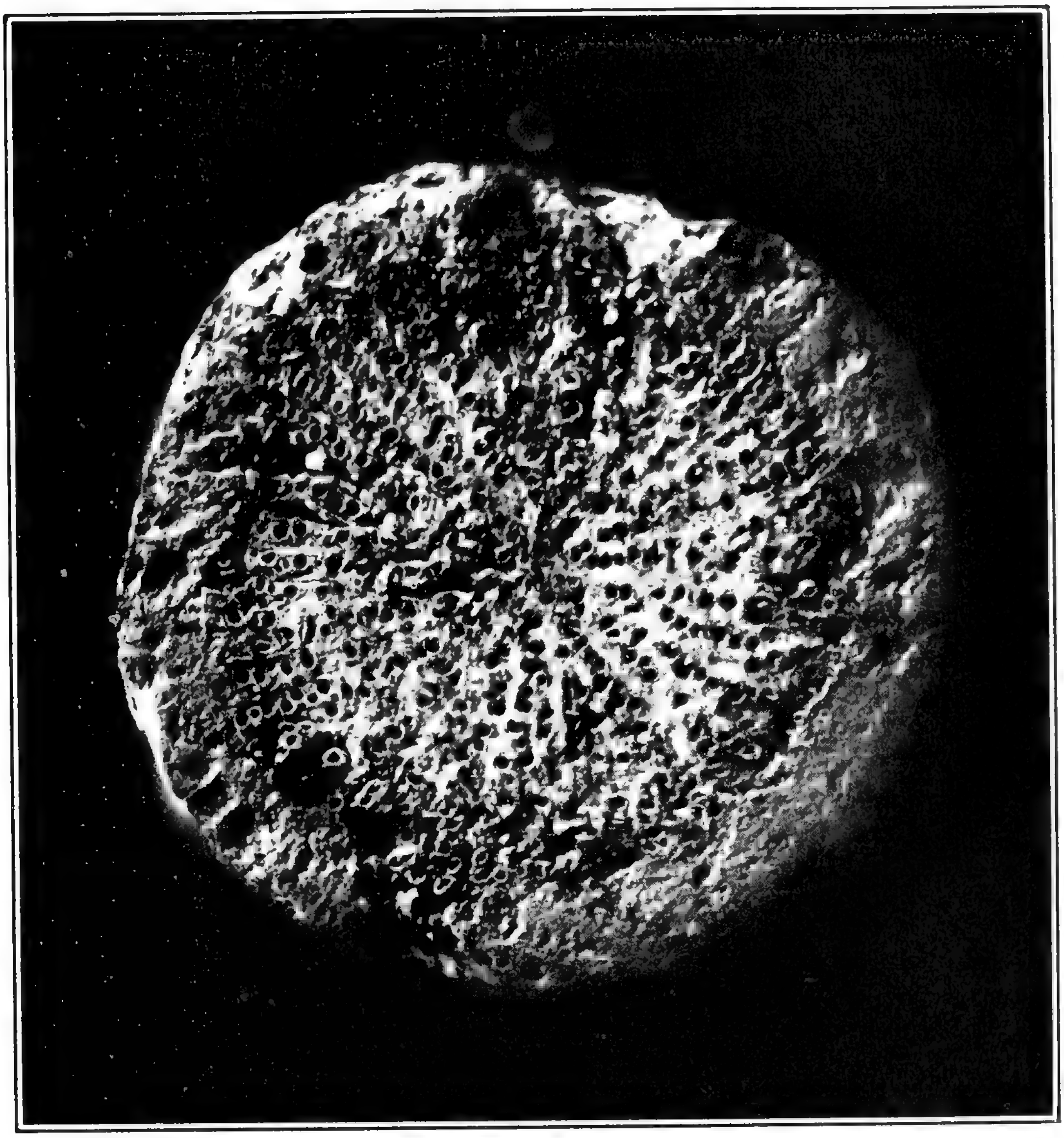
! Naras roots, twigs and young plants.

W. Versfeld and G. F. Britten.—The ! Naras Plant.



!Naras Fruit cut in half.

W. VERSFELD AND G. F. BRITTEN.—THE !NARAS PLANT.



Section of ! Naras root shewing air and water channels.
(*Twice natural size*).

drifting sand. It occurs most plentifully in what was once the wide estuary of the Kuisip River. Since this estuary was formed the amount of water brought down by the river has decreased until at present there is very rarely sufficient to flow over the surface of the sand which has been blown into it from the south. A considerable amount, however, finds its way to the sea underneath the sand. The ! Naras fields occupy practically the whole of the estuary with the exception of about three miles at the coast. The south bank of the estuary coincides roughly with the southern boundary of the British territory of Walfish Bay.

Nature of the Plant and Fruit.

The ! Naras (*Acanthosicyos horrida*) is a cucurbitaceous plant, belonging to the same family as the cucumber, pumpkin, and the various melons. Unlike the other members of the family, which possess highly developed leaves, this plant has no leaves at all, unless the tiny scale-like growth, which appears on the young plant, but soon drops off, can be called by that name. This is a provision made by Nature to allow the plant to remain unhampered by the weight of the sand which is constantly blown upon it. The plant forms an almost impenetrable hedge of interlacing twigs, carrying pairs of straight thorns at very short intervals—less than an inch in the case of the smaller twigs. The roots, which are usually of enormous length, since they reach from the vine on top of a sand-dune to the water below it, resemble bundles of capillary tubes arranged roughly in lines radiating from the centre, with a layer of protecting bark outside. These tubes, which are large enough to admit a small pin, form the channels through which water and air are supplied to the whole plant. The branches and thorns contain chlorophyll, and thus perform the functions of leaves in absorbing carbon dioxide from the air.

The fruit, which is light green in colour when ripe, is a small melon about 6 inches in diameter, covered with small protuberances. It consists of an outer rind and six segments (similar to those of an orange) containing numerous seeds, resembling those of a musk-melon, but considerably larger and more rounded.

The conditions under which the plant grows are most exceptional. It is certainly unusual to find a green plant, and a useful one to boot, flourishing on the top of a dune of loose desert sand in a desert climate. As these dunes are of considerable height, and water is found only below their base, the roots of the plant must reach down to a very great depth. It is not surprising that it was presumed that the plant could be cultivated in any desert region, but to understand the facts of the case it is necessary to go back to the earlier stages of the growth of an individual plant. It is absurd to imagine that a young Naras seedling can be planted on the top of a large dry

sand-dune with any chance of surviving. When a seed germinates in damp soil in which the water gradually subsides, the young roots will naturally extend deeper and deeper in search of the water. But it may also happen that the plant, little by little, gets covered up with wind-blown sand. In such a case the shoots succeed in growing through the overlying sand. This process is carried on until the top of the plant is as much as 60 feet above the spot where it first grew. It has been stated that some roots are 350 feet long, but this is hard to believe, as the dunes do not attain to that height. It is evident that what we now call roots were in many cases orginally the stems of the plants. One can understand that under such circumstances leaves would be a serious encumbrance to the growth of the plant, besides being easily scorched by the sun. In course of time leaves have been entirely discarded, their functions being performed by the shoots and thorns.

The flowering season commences about October, and the fruit ripens about Christmas time, and remains in season for four or five months.

Uses of the Fruit.

Fish and !Naras fruit form practically the only articles of diet of the wretched desert dwellers of the Walfish Bay territory —mostly Topnaar Hottentots and Bushmen. During the season the fruit is simply consumed as required, but to make provision for the rest of the year the remainder of the fruit gathered is boiled until it forms a thick soup, strained through a roughly-made basket or perforated paraffin tin on to the dry sand, where it forms a flat cake which, when dry, resembles dark "mebos" in appearance, but is rather tough. This is eaten as it is, or is again boiled and formed into a thick, nutritious soup. When eaten by those unaccustomed to its use, it causes swelling and a burning sensation in the mouth.

The fruit has a sweet, sour taste when ripe, but is intensely bitter when green. The roots and twigs also have a very bitter taste, and are used medicinally by the natives.

The seeds are eaten both raw and boiled. The natives usually grind the seeds, including the husks, between two stones, and boil the meal thus obtained. The seeds have a rich nutty flavour and a high feeding value. The boiled seeds, which contain less oil than the raw, but have a richer flavour, at one time formed an article of trade under the name of "Butterpits." These are eaten like nuts, and are also used in the making of confectionery. There is no doubt that if a regular supply were aassured, the demand would increase very considerably.

Composition of the Fruit.

It was with great difficulty that ripe fruits were procured for the experiments, the results of which are given below. On

one occasion all the fruits sent were spoiled, though plucked from the plant before they were ripe. On another occasion only two survived the long journey to Capetown. These were examined separately. The seeds from the over-ripe fruits were also analysed. The rind of the fruit was in each case separated from the pulp and the husks of the seeds from the kernels.

The following results were obtained:—

Air-dried Samples.

	Moisture per cent.	Protein per cent.	Fat per cent.	Ash per cent.	Digestible Carbohydrates per cent.	Fibre per cent.
Smaller Fruit:						
Rind	2.09	9.63	2.22	12.43	45.63	28.00
Pulp	3.41	11.38	7.04	14.31	56.84	7.02
Husks of seeds	15.54	3.07	0.75	0.67	21.57	58.40
Kernels of seeds	11.28	38.68	44.44	3.28	2.32	
Larger Fruit:						
Rind	2.73	10.72	2.00	10.81	45.94	27.80
Pulp	1.73	14.44	10.69	12.71	54.93	5.50
Husks of seeds	16.81	2.71	0.67	0.76	19.78	59.27
Kernels of seeds	20.37	30.22	44.28	3.30	1.83	
Over-ripe Fruit (a):						
Husks of seeds	9.95	3.94	1.37	1.23	18.97	64.54
Kernels of seeds	6.50	35.73	52.17	3.50	1.27	0.83
Over-ripe Fruit (b):						
Husks of seeds	9.45	3.50	1.34	1.14	19.31	65.26
Kernels of seeds	5.20	35.30	53.30	3.75	1.53	0.92

When calculated on the fresh fruit, which contains a considerable amount of moisture, the following figures are obtained for the rind and pulp:—

	Moisture per cent.	Protein per cent.	Fat per cent	Ash per cent.	Digestible Carbohydrates per cent.	Fibre per cent.
Smaller Fruit:						
Rind	82.67	1.70	0.39	2.20	8.08	4.96
Pulp	83.29	1.97	1.22	2.48	9.83	1.21
Larger Fruit:						
Rind	83.96	1.79	0.33	1.81	7.67	4.64
Pulp	91.45	1.26	0.92	1.11	4.78	0.48

The total sugar (reckoned as dextrose) in the pulp of the larger fruit before drying was found to amount to 4.13 per cent.

The following determinations were also made:—

	Smaller Fruit.	Larger Fruit.	Over-ripe Fruit. (*a*)	Over-ripe Fruit. (*b*)
Weight of fruit*	532.5	682.5		
Percentage of rind	28.85	29.79		
Percentage of pulp...	57.09	61.74		
Percentage of seed...	14.06	8.47		
Diameter of fruit...	11 cm.	15 cm.		
Thickness of rind...	.35 to .7 cm.	.35 to .7 cm.		
Number of seeds...	195	148	200	200
Weight of seeds	74.9	57.8	66.6	52.6
Average weight of each seed	.384	.390	.333	.263
Weight of husks	31.6	20.2	25.1	21.0
Weight of kernels...	43.3	37.6	41.5	31.6
Percentage of husks	42.19	34.95	37.69	39.92
Percentage of kernels	57.81	65.05	62.31	60.08
Length of seeds	1.3 to 1.6 cm.	1.3 to 1.6 cm.		
Thickness of seeds	.4 to .6 cm.	.4 to .6 cm.		
Thickness of husks	.3 to .4 mm.	.3 to .4 mm.		

It will be seen from the above figures that the !Naras fruit has excellent feeding qualities, the pulp being rich in carbohydrates and the seeds in protein and fat. The "!Naras cake," which is stored away for food when the fruit is out of season, should be similar in composition to the air-dried samples.

A peculiar property of the juice of the fruit is its action on milk. In connection with this matter, experiments conducted some time ago by Dr. R. Marloth showed that the juice of the fresh fruit contains a non-volatile active principle which has an effect on milk similar to that of rennet, and that one teaspoonful of the juice can coagulate one and a half gallons of milk.

NATURE OF WALFISH BAY SOILS.

The question of soils and plant foods is of very great importance—far greater than one would imagine on hearing that the !Naras plant grows on sand-dunes. The term "sand-dunes" immediately suggests white or yellow quartz sand practically devoid of any plant food. The Kuisip River soils, however, are of an entirely different type, as will appear below.

The soils examined were the following:—

A.—*Soils in which !Naras plants grow*—

1. Surface sample from three holes at Haroas.
2. Subsoil of No. 1.
3. Surface sample from three holes at Wortel.
4. Subsoil of No. 3.

B.—*Soils in which !Naras plants will not grow*—

1. Surface.
2. Subsoil.
3. Lumps of dark shaly matter found in No. 1.

C.—Soil from Namieb Desert taken at Trigonometrical Station U.P.2 at depth of 12 inches, the coarse white sand on the surface having been removed.

* This weight and all other weights in this table are expressed in grammes.

D.—Soil taken about one mile from Walfish Bay, north of the Kuisip River, where Dr. Macdonald indicated the possibility of cultivating large wheat fields.

All the samples in series A and B are from the Kuisip River estuary. These are of a most unusual character, differing most essentially from ordinary desert sand, which consists almost entirely of quartz grains, by having a large proportion of small particles of white mica, a mineral containing a large percentage of the valuable plant food potash. Sample A4 contained less mica and more quartz than the rest. Sample B1 contained a large proportion of various-sized lumps of dark shaly matter, greatly decomposed. As these lumps are very different from the surrounding sand, but are soft enough to be penetrated by roots, they were separately analysed (see B3).

Partial mechanical analyses were made of these soils, and for the purposes of this paper it is sufficient to say that the general type is a fine sandy soil, perfectly porous, containing little or no clay, and very uniform in grain, the particles being mostly just under ½-millimetre in diameter.

The results of the analyses for reserve of plant foods are given below in detail, the figures representing percentages, calculated on the original air-dried soil.

	A.—Soils in which the !Naras Plant thrives.					B.—Soils in which the !Naras plant will not grow.		
	A 1	A 2	A 3	A 4		B 1	B 2	B 3
Moisture	0.54	0.73	0.48	0.16	..	0.50	0.53	14.84
Loss on ignition	2.30	2.51	2.32	0.67	..	5.14	1.91	9.25
Chlorine	.075	.152	.034	.011	..	3.569	1.099	7.021
Soluble Salts	.152	.384	.112	.040	..	5.736	1.848	11.060
Nitrogen	trace	trace	trace	trace	..	.061	.014	.119
Lime	.550	.500	.660	.316	..	.947	.656	1.634
Magnesia	.066	.064	.126	.041	..	.411	.483	.601
Potash	.575	.573	.560	.079	..	.399	.240	.502
Phosphoric Oxide	.130	.139	.151	.069	..	.137	.102	.165

The outstanding feature in connection with these soils is the extraordinarily high percentage of the important plant food potash, a substance particularly required by plants which produce sugar. It is obvious that the potash is derived from the micas of which the soils largely consist. It is noticed that sample A4, which contains less mica than any of the others, has also the least potash. There is, of course, considerably more total potash in the soils than is indicated by the above figures, which give only the amount available as plant food. As the mica gradually decomposes more and more potash becomes "available," so that a soil of this description has practically an inexhaustible supply.

Since the soils on which the plants will not grow, though containing somewhat less potash than the good soils, are still quite rich in this plant food, we have to look further for the cause of their inferiority. The percentages of the other plant foods in both series are very satisfactory, more so, on the whole,

than in the case of most agricultural soils, except with regard to nitrogen, of which the !Naras soils contain only traces. The plant, however, does not seem to mind this deficiency. Does it get its nitrogen directly from the air?

We see, thus, that the unsuitable soils are little, if at all, inferior to the others—in fact, they have considerably more nitrogen. It is when we come to look at the figures for chlorine and soluble salts—the injurious constituents—that a marked difference is seen. It is evident that the inferiority of the B series of soils is due entirely to their containing a very large amount of injurious salts, mostly common salt. It is absurd to expect any plant to grow in a soil containing from 2 to 11 per cent. of common salt. This appears to be the condition of all the soils within three miles of the coast.

Of the other soils examined, that from the Namieb Desert is a most unusual type of soil—if soil it can be called—consisting mostly of gypsum and fragments of quartz, and containing very little of the usual constituents of soil, namely, clay and sand. Information is not available as to whether it is representative of any large extent of country. In any case it has not much bearing on the question of !Naras cultivation.

Both this soil and the other sampled north of the Kuisip River were found to contain about .5 per cent. of common salt, and these soils are thus unlikely to be suitable for any agricultural purposes.

So we see that the !Naras plant does not possess the marvellous powers attributed to it, namely, of being able practically to "live on air.' It has a sufficiency of water and an excellent supply of plant foods, produced in the disintegration of plutonic rocks and crystalline schists, which occur very extensively on the west coast of South Africa. If it could be ascertained that at the other localities where the !Naras occurs, soils similar to those of the Kuisip River are found, the question of the possiblity of cultivating the plant in other desert localities would be definitely settled. It will most likely prove impossible of cultivation elsewhere than in localities where conditions with regard to water, soil, and climate are similar to those at Walfish Bay.

SOUTHERN STARS.—Scientific research in South Africa has hitherto achieved comparatively little: it is of recent date; and in very few branches of science has there been any research worthy the name. To such statements the science of astronomy offers a notable exception. We mention the name of Lacaille, and at once our thoughts go back more than a century and a half. Since Lacaille's day much has been accomplished astronomically in South Africa, and occasionally the southern observers have set the pace for their *confrères* oversea. But we need more observers, and the best way of securing them is —as in other sciences—to get them interested in the study from

youthful age. The little book* recently published by Miss M. A. Orr (Mrs. John Evershed) will surely awaken such an interest amongst the young, and even on the part of many who are no longer youthful. It may have the effect of recruiting several for the army of observers, which the various sections of the British Astronomical Association will gladly enlist in their ranks. How the relative ages of various stars may be gauged is one of the fascinating subjects which the authoress makes plain, and the future astronomical specialist may find himself in an *embarras de richesse* when he reads of star clusters, of nebulæ, of the milky way, of variable and eclipsing stars, and of double and multiple stars, subjects which are at the same time clearly and concisely explained. The book is written for those who have not read much about astronomy, and who have only an opera-glass or small telescope, or perhaps no instrument but their unaided eyes for examining the stars, but one may safely predict that all who thus practically apply the chapter on double stars will be strongly tempted to acquire more powerful instruments. Amongst the southern double stars enumerated is, of course, α Centauri, our nearest star neighbour, and, in addition, the reader is impelled to personal observation by reading of such fine coloured pairs of stars as σ Scorpii, one of which is white, and its neighbour blue; δ Corvi, pale yellow and bluish; 32 Eridani, yellow and blue-green; β Capricorni, orange yellow and blue; γ Leporis with its crimson companion, and so on. From these the observer may be led to the study of such coloured doubles (not necessarily southern) as γ Andromedæ, orange and green; α Canum Venatici, golden and lilac; α Herculis, ruby and emerald; 94 Aquarii, rose and greenish; η Cassiopeiæ, golden and purple. From the mere popular point of view, there is scarcely a more attractive pursuit for the embryo astronomer than the study of the great number of coloured double stars, and here, as in other respects, he will find sufficient in Mrs. Evershed's little book to stir him up to seek further knowledge.

TRANSACTIONS OF SOCIETIES.

Geological Society of South Africa.—Monday, June 14th: Mr. D. Wilkinson in the chair.—"*The Upper Witwatersrand System*": Dr. E. T. **Mellor.** The general features of the Upper Witwatersrand System are well known: the author, however, considered that there were uncertainties in several directions that needed clearing up, and this was the main object of the paper. Particular consideration was given to the degree of continuity of the various members of the system, and the variations in thickness which they exhibit when followed from end to end of the Rand. The author's descriptions and conclusions were mainly based upon observations made during five years occupied in mapping the whole Witwatersrand area, during which period the underground workings of a large number of mines were visited.

* M. A. Orr: "*Stars of the Southern Skies*," pp. xii, 92. 8 × $4\frac{1}{2}$in., illus. London: Longmans, Green & Co. 1915. 2s. 6d.

Monday, July 5th: Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S., Vice-President, in the chair.—"*The East Rand*": Dr. E. T. **Mellor.** Some of the main features of the geology of the Eastern Witwatersrand were dealt with on lines similar to those adopted by the author in previous papers relating to the Western and Central portions of the Rand.

Monday, July 26th: Prof R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S., Vice-President in the chair.—"*The Geology of part of Namaqualand*": Dr. A. W. **Rogers.** A geological description of the north-western part of the Division of Namaqualand, inclusive of the coast belt, a considerable part of the Namaqualand highlands, and the slope connecting those two regions. Only the structure of rocks of pre-Karroo age was described —"*The Dwyka Series in South-West Africa*": Dr. P. A. **Wagner.** An account of the author's observations and conclusions with regard to the Dwyka series as met with in the Protectorate of South-West Africa (late German South-West Africa). Incidentally objection was taken to the indiscriminate application of the term "tillite" to true morainal deposits as well as to the southern "Dwyka," a normal sediment laid down under water. The author proposed to apply the term "Dwyka conglomerate" only to the true bedded and boulder conglomerates of the series, reserving the term "tillite" for deposits of morainal character, and "Dwyka boulder mudstone" for the peculiar rock extensively developed in the southern part of the Cape Province. Boulder mudstones presenting precisely similar feature to the latter occur over wide areas of the Keetmanshoop District. The principal geological formations of the area are (1) superficial deposits, comprising Kalahari sand and Kalahari limestone. (2) Karroo System, Dwyka Series, and (3) Nama system, Fish River, or Zwart Modder Series. The intrusive igneous rocks, Karroo dolerite and Kimberlite are also represented: the latter, in a fairly large pipe apparently barren of diamonds occurs at Rietfontein, Gordonia.

South African Society of Civil Engineers.—Wednesday, August 11th: R. W. Menmuir, A.M.I.C.E., Vice-President, in the chair.—"*Road construction and maintenance in Johannesburg*": G. S. Burt **Andrews.** Road construction and maintenance in Johannesburg suffer from special disadvantages, such as (1) excessive length of roads compared with population, (2) difficulty of obtaining suitable material, (3) climatic conditions and traffic, (4) method of obtaining funds (5) lack of regulations for development of townships, (6) the extraordinarily rapid growth of the town. One of the most difficult problems in Johannesburg is the upkeep of unmacadamised roads, and on the macadamised roads one of the greatest drawbacks is the formation of dust in dry, and of mud in rainy weather, the dust nuisance being particularly noticeable. The initial cost of the macadamised roads is £2,640 per mile, and the cost of maintenance about £880 per mile per annum.—"*Construction management*": F. T. **Patterson.** The author urged that young engineers, trained in South Africa, should be assisted to develop the energy and ability essential in rapid and economical carrying out of engineering construction. The management of labour forces for engineering works must be scientifically carried out. The policy of the future should be to encourage rather than drive employees to return good output for wages received, and the fundamental basis of a civil engineer's professional training must include the study of difficulties and devising ways of overcoming them. As evidence of the need of change, it was emphasised that the cost of carrying out works is probably higher within the Union than anywhere else in the world.

NEW BOOKS.

Eveleigh, Rev. W. —"*South-West Africa*," $7\frac{1}{2} \times 5\frac{1}{2}$ in., pp. viii. 260. London: T. Fisher Unwin. 1915. 5s. nett.

Macdonald, William.—"*The Settler and South Africa*" $7\frac{1}{2} \times 5\frac{1}{2}$ in. pp. 159. illus. London: Union-Castle Line. 1914. 6d.

Ritchie, Moore.—"*With Botha in the field.*" 12mo. Maps and illus. London: Longmans, Green & Co. 1915. 8 oz. 2s. 6d.

THE BAGANANOA OR MA-LABOCH: NOTES ON THEIR EARLY HISTORY, CUSTOMS, AND CREED.

By Rev. Noel Roberts.

(Plates 5-7.)

The Bagananoa.

The Bagananoa, or Malaboch, are Bantus speaking a language akin to Sepedi. They occupy a strong position on the Blaauwberg Mountain, in the Northern Transvaal, which they have held for about a century and a half.

The information in this paper has been gathered almost entirely from the natives themselves, chief among whom may be mentioned the present ruler of the tribe, Kgalushi Malaboch, and one of his head indunas. Especial mention should be made of Mr. C. A. T. Winter, who has not only acted as interpreter on several occasions, but has done everything in his power to help me in getting information.

The Bagananoa, like other Bantu tribes, regard themselves as a distinct species of the genus *Bantu,* and the conception of a Specific or Tribal Spirit or Soul, uniting all members of the tribe, is strongly developed. Further, it is believed that this Tribal Spirit is bound by the closest ties of kinship to the Spirit uniting all individuals in a species of animal, the particular species in each case being known as the *Siboko,* or Totem of the Clan. In the minds of most natives there is considerable confusion between their conception of the human Tribal Spirit, and its animal counterpart the Siboko, and it will be found that the two are regarded as identical, or, at least, co-incident. Their real relation can best be illustrated by means of a diagram as follows:—

<table>
<tr><td>Individual members of Malaboch Tribe</td><td>united by Ancestral Spirit of Tribe.</td><td rowspan="2">uniting to form Malaboch Tribe, a unit in the</td><td rowspan="6">Bantu Race.</td></tr>
<tr><td>All animals of the Species Duiker.</td><td>Collective Life of which = Siboko.</td></tr>
<tr><td>Individual members of Malabolo Tribe.</td><td>united by Ancestral Spirit of Tribe</td><td rowspan="2">uniting to form Mamabolo Tribe a unit in the</td></tr>
<tr><td>All animals of the Species Wild Pig.</td><td>Collective Life of which = Siboko.</td></tr>
<tr><td>Sekukuni's people etc.</td><td>Ancestral Tribal Spirits.</td><td rowspan="2">uniting to form Sekukuni or other Tribes, units in</td></tr>
<tr><td>Porcupine or other Totem animals.</td><td>Tribal Sibokos.</td></tr>
</table>

Since all members of a clan in communion with one species of animal are regarded collectively as a unit in the Bantu race, it naturally follows that the tribes should be distinguished from one another by their Siboko. As an interesting illustration of this, it may be noticed that the system of divination most widely practised among the Bantu peoples is that of Astragalomancy. If a witch-doctor's set of "bones" be examined, it will be found to consist very largely of the huckle-bones of different animals. Each astragalus represents the *animal* from which it was taken, and therefore the *tribe* of which that animal is Siboko. In a case of theft, for example, the signs pointing to the huckle-bone of a *pig* would be quite sufficient evidence in the eyes of a native to lay the guilt at the door of a member of the "pig" tribe.

Moreover, certain figures, representing the motions of the sibokal animal, are performed in the course of their ceremonial dances, so that the tribal origin of a man may be known by his dance. Therefore, when a native wishes to know the tribe of a stranger, he will invariably ask: "What dance do you dance?"

There is an apparent confusion with regard to the Siboko of the Bagananoa, for if this question be addressed to one of the people of Malaboch, he will reply: "*Di choene*" (*i.e.*, the Baboon). A further question, however, will elicit the information that the Baboon is not regarded as the Siboko of the tribe, and this is proved by the fact that the Bagananoa eat the flesh of a Baboon with relish. Their Siboko, he will tell you, is the *Puti*, or Duiker (*Cephalophus Grimmi* Gray). In explanation of this the present generation say that the nickname "Baboon" was applied to them on account of their inaccessible position among the rocks of the mountain, and that the name has clung to them.* The totemistic position of the tribe is further complicated by the fact that though the Duiker is treated with all the honour accorded to a Totem (*i.e.*, it is Taboo to all members of the tribe) the animal whose spirit is believed to be in communion with the Spirit of their forefathers is the *Kuena*, or crocodile. An image of this animal is actually worshipped, as I shall presently show, and I was told by Mr. Key that when he was Sub-Native Commissioner at Blaauwberg, great offence was given by one of the police there who killed a crocodile, and hung the skin up on his verandah as a trophy. This puzzling position is partly explained by Mrs. Franz, who tells me that it is usual for a clan leaving the parent tribe to adopt a new Siboko—the first animal seen on arriving at their new home.

The facts are not without value as they provide evidence in confirmation of some of their traditions, and help us to trace the evolution of the tribe.

* According to Stow, the Baboon was the Siboko of the Ba-hurutsi, from whom the Bagananoa are probably descended.

Traditional History.

The Bagananoa are supposed to be an offshoot of the Bahurutsi,* one of the divisions of the Bakuena who invaded the country from the North. The earliest known chief, according to tradition, was Maliti, who settled down in some mountains in Northern Bechuanaland, which were called after his name.

This Maliti was the great-great-grandfather of the present chief, Kgalushi Malaboch. He had two sons. The younger of these, Lebogo, seems to have been a man of fine character, and great ability, and as he grew up a rivalry between him and his elder brother, the rightful heir to their father's throne, was inevitable. A gentle disposition and courteous manners, combined with unquestionable boldness and courage, and an indomitable will, secured for Lebogo a large following in the tribe, but under the wise and firm rule of their father, no open rupture between the brothers took place for many years.

At the time our history commences, the whole country, in what is now the Northern Transvaal, was suffering severely from drought and famine. The scarcity of food led a party of Modjadji's people to leave their homes in search of supplies. They carried with them a number of iron hoes of their own manufacture to barter for food. By the time they reached the Bahurutsi, however, they were nearly dying of starvation.

One of the leaders of the band was a princess of the royal house of Modjadji, a winsome maid, who at once captured the heart of Lebogo. He took her to his home, fed her, and cared for her till her health and strength were restored.

The bundles of hoes carried by the strangers seem to have awakened the curiosity of Lebogo, and in answering his questions, the girl was astonished to find that the whole tribe subsisted chiefly on meat, and knew nothing whatever about agriculture. She therefore promised Lebogo that she would teach him the use of the hoe, and instruct his people in the art of planting seed, and tilling the ground. When the time came, however, her labourers in the field were greeted by derisive cheers by the Bahurutsi women, and as the days passed, and their prognostications of failure seemed as though they would be realised owing to the parched condition of the ground, she turned upon Lebogo in anger and reproached him for not providing rain. The foreign maid came from a country whose chieftain queens were recognised throughout the Bantu world as the greatest rainmakers upon earth, and according to the current belief of the time, that the power of rainmaking was vested in the royal family, she naturally expected that Lebogo, or at least his father, would be able to control the rain in his own district. Lebogo convinced her of his ignorance, so she determined to impart all her own knowledge on the subject (which must have been considerable) to him, lest her lesson in

* *Cf.* Govt. Report.

agriculture should fail and she become an object of ridicule in the tribe. The magic of Lebogo, carried out under her directions, was successful. Clouds appeared, the sky was darkened, the lightning flashed, the thunder rolled, and in the abundance of rain which followed, the claims of the foreign maid were fully vindicated. A few weeks later, when the seed she had sown had sprung up, and she had reaped a good crop of grain, her reputation for wisdom was firmly established in the tribe. The Bahurutsi women were not long in following her example, and soon a brisk trade in hoes was followed by the establishment of agricultural labour in the fields, and to this day the women still hoe the ground, plant seed, and reap the crops.

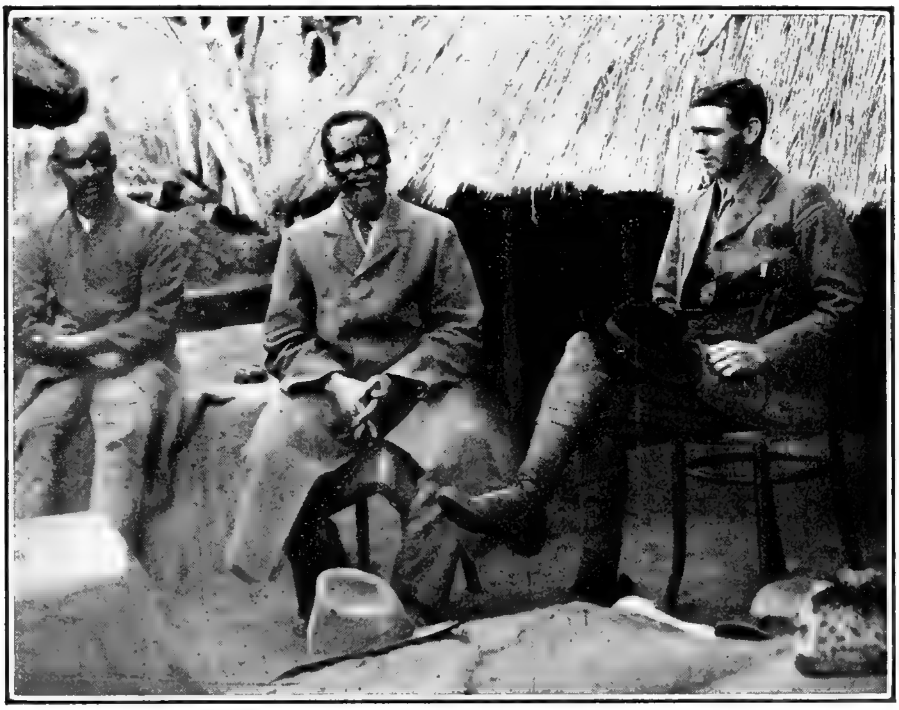
The magic rights and formulæ used in the art of rain-making are still jealously guarded by the chiefs of the tribe, and even now Malaboch enjoys a reputation second only to that of Modjadji as a rain-maker.

The effect of these incidents on the political situation may well be imagined. The hands of the Lebogo faction were greatly strengthened, and the elder brother saw that his cause was becoming hopeless. There was a way out of the difficulty, however; if he were to marry this wonderful stranger, a blow would be struck at the prestige of Lebogo, and he would regain much of the power he had lost. He therefore tried to induce her to become his wife. With fine scorn the girl rejected his advances, declaring that had it not been for Lebogo, she would have died the death of a dog. The young chief was furious. Nay more, he was desperate. If he wished to secure his position as his father's heir there was only one thing to be done. Lebogo must die.

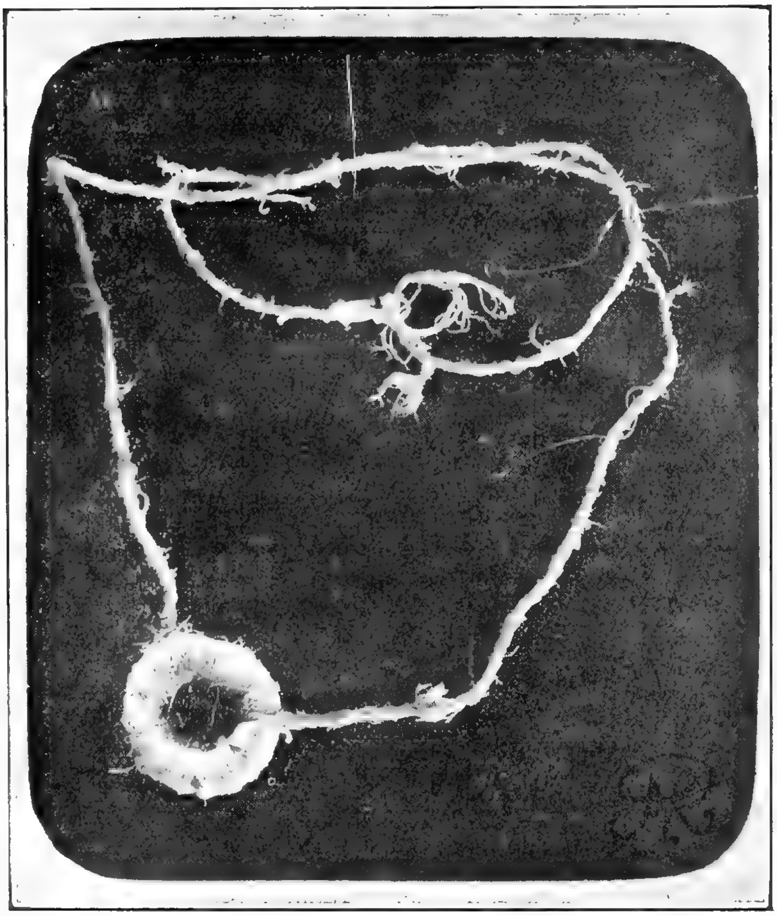
A plot to assassinate him was therefore set on foot, but news of the conspiracy reached the ears of the chief, who thereupon informed Lebogo, and advised him to leave the tribal home and settle elsewhere.

The young man determined to act on this advice, and taking with him a band of chosen followers, he crossed the Magalakwin, and made for the Blaauwberg, on the pretence of hunting conies. The mountain was then occupied by the Magoela. Lebogo visited the chief of that tribe, and begged permission to come and settle in the district with his people. Permission was refused, so spies were despatched to every kraal of the Magoela, and an estimate of the fighting strength of the tribe was made, with the result that Lebogo decided to take possession of the mountain by force. The party then returned home. Secret instructions were at once issued to all those who supported the cause of Lebogo, and in the dead of night the exodus of the *Ma-lebogo* was successfully carried out without being discovered by the rest of the tribe.

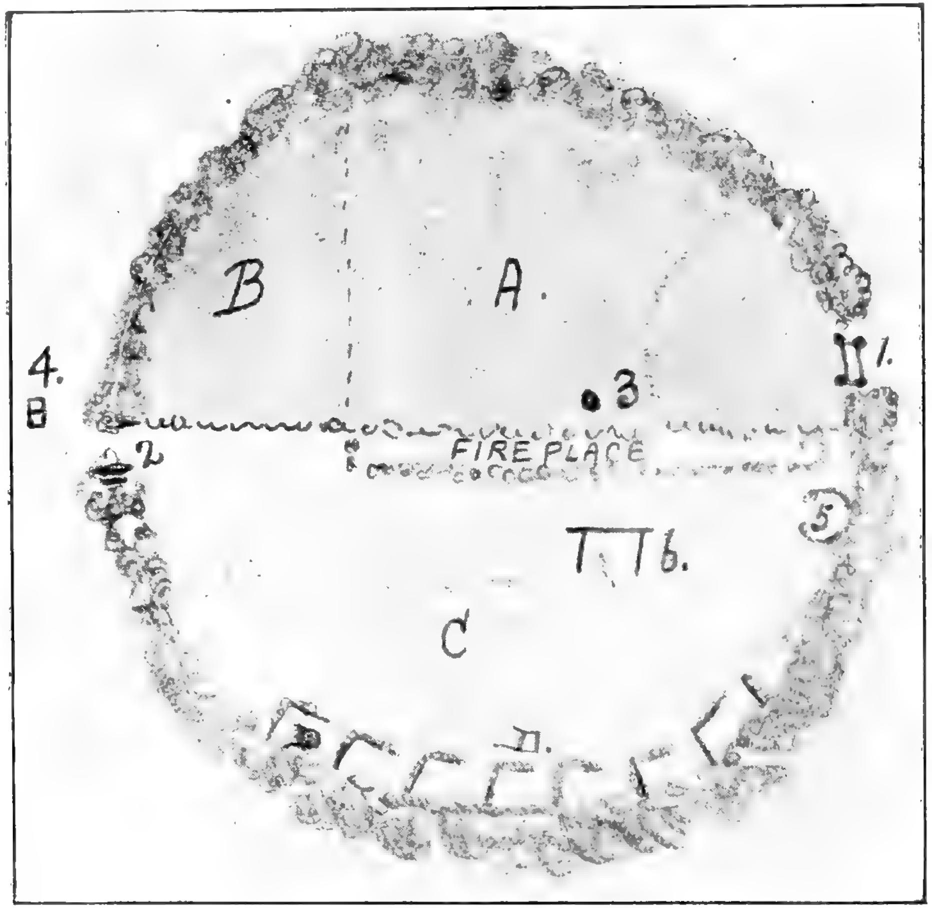
The old chief advised Lebogo to make a forced march to "the river," and then to entrench himself on the further bank,



Chief Malaboch at home.

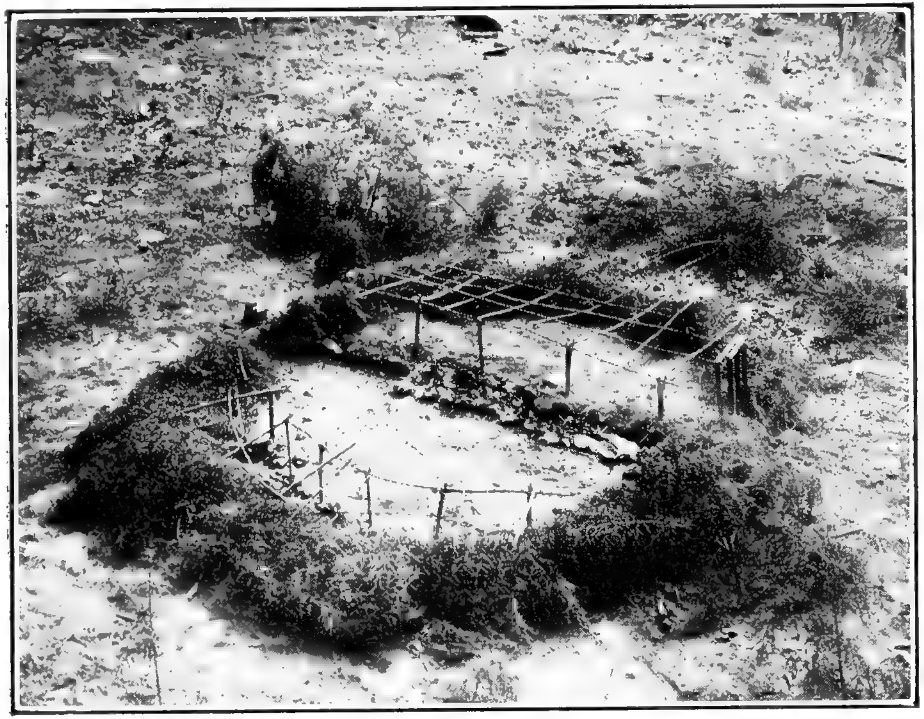


The "Kgolego."



Ground plan of Malaboch Lodge.

A.—Part of platform reserved for the older Men.
B.—Part of platform used by the *Mamatsahoana*.
C.—Space occupied by *Badikana*, and used for dancing, etc.
D.—Initiates' dormitory.



Appearance of Lodge at the end of the Second Day.

1.—Tsela ea boyatatanye (Men's entrance).
2.—Tsela ea Baloi (Boys' entrance).
3.—The throne or Chief's seat.
4.—The Mogalabye (Circumcision Stool).
5.—The Crocodile's hut.
6.—The Tlo otshe, (Sacred Elephant).

where he would have some chance of defending himself in case he were attacked by his brother, and this advice was followed. When morning came, and the flight was discovered, Lebogo's brother at once went to his father, and asked for permission to follow up the refugees and punish them for their desertion. The crafty old man replied that they might do so, but if they found Lebogo had got across the river they were to give up the pursuit and return home.

The refugees had hardly finished their morning meal when the alarm was given, and the pursuing warriors appeared on the further bank of the river. The enemy, however, did not attempt to cross the stream, and after hurling insults and reproaches at them the pursuit was abandoned. Among other epithets applied to them that day was that of *Bagananoa**, a name by which they have been known ever since.

Continuing their flight in a south-easterly direction, the Bagananoa came at length to the foot of the Blaauwberg range, and camped on the present farm Witstein. Leaving their women and children at this spot, Lebogo and his warriors scaled the mountain, and advancing to the hoofd-stad of the Magoela,† he again applied for permission to settle there. The request was refused, and a battle thereupon ensued, resulting in a victory for the Ma-laboch. In a very short time their position on the mountain was firmly established, and they have remained there ever since.

The Initiation Rites of the Bagananoa.

No male member of the tribe is allowed to take any part in the Councils of the Kraal or to exercise any of the privileges of manhood until he has been circumcised and further initiated in the secret mysteries. This usually takes place between the ages of ten and seventeen years. The ceremonies last about three months, commencing at the time of the "Kaffir-corn" harvest, and are usually arranged to be held when the son of a chief, or one of the Indunas attains the age of puberty. Preparations are made for weeks beforehand. Branches of trees are prepared, grass is cut, and the low walls of stone, which form the basis of the Mphato or lodge enclosure, are put in order. (See Plate 6.) Upon this foundation piles of brushwood are heaped, and a thick, impenetrable fence, quite impervious to sight, and of a sufficient height effectually to conceal all that goes on within the enclosure, is erected. On the side facing due east an entrance is left, and this is finished off by a doorway composed of two straight poles of the wild fig tree

* Bagananoa = the deniers, refusers, or quarrellers.—C. A. T. Winter.

† According to "Short History of Nat. Tribes of Transv.," issued by Native Affairs Department, 1905, these people were called *Madebana*. The chief Malaboch told me that the people they found living on the mountain were the *Masetedi*—"a tall, pale, long-haired race."

(*Mohoio*) on each side, surmounted by two more poles of the same kind to form a lintel. (Plate 6, No. 1.) These poles are covered with their bark, which must be in perfect condition, the least scratch or cut being sufficient to render them unfit for use. This entrance is called the *Tsela ea boratatanye* (the way of the fathers), and is strictly reserved for the use of *men* only. On the opposite side of the enclosure, facing the setting sun, is another gate, the *Tsela ea Baloi* (wizard's entrance), which is used by the Initiates and their keepers. (Plate 6, No. 2.) The northern part of the enclosure is raised about two feet above the level of the rest, forming a platform (Plate 6, A and B), the front of which is faced by a low stone wall. When the preparations have been completed, two flat stones from the hearth of the chief are brought down the mountain and fixed in position close to the northern side of the western entrance, outside the *Mphato*. This is the *Mogalabye* (old man), or Circumcision Chair (Plate 6, No. 4).

The boys who are to be initiated are summoned to the headman's kraal the night before, and at dawn the whole party marches out to the *Mphato*. They halt near the eastern gate, and the "stert-riems" of the boys are removed, and hung up on a thorn tree hard by. Afterwards the best of these are picked out by the Chief Indunas for the use of their children; the rest are burned at the close of the ceremonies. Each initiate (*Modikana*) is now placed under the care of a youth, who has already been initiated, usually an elder brother or some near relation, who accompanies him everywhere outside the enclosure, and waits on him, or bullies him at other times. These wardens are called *Mamatsahoana* (little stones used for supporting a pot over a camp fire). The "stert-riems" having been removed, the initiates are surrounded by *Mamatsahoana*, and men, and a great noise of shouting and singing is commenced, and kept up without intermission until the first part of the ceremony is over. The chief's son, or the boy of highest rank, is taken out from the rest, and walking by the side of one of the *Mamatsahoana*, hidden under the skin cloak of the former,* he is led round the outside of the enclosure to the western entrance. Here he is seated on the *Mogalabye*, with his legs wide apart. Two warders seize him by the ankles, two more grasp his arms, and a fifth, standing behind him, blindfolds the boy by holding his hands over his eyes.

Before him squats the surgeon, the *'Mpakana oa banna* (the little knife of the men), armed with his knife and a cloven stick. The foreskin is clipped between the blades of this primitive forceps, the head depressed, and the operation performed. A soft, woven ring of fig-tree fibre (*Ficus elastica*?) is then pushed over to the base of the organ, and suspended by cords from the boy's waist. This ring, called the *Kgolego* (the

* *Cf.* "Customs of the World," **1**, 141.

bond) (Plate 5, Fig. 2) not only acts as a tourniquet, but serves as a support and keeps the bleeding wound away from the scrotum. It is worn until the scar has completely healed. A stock of these rings of different sizes is prepared beforehand, and is kept ready for use within the surgeon's reach. The *Kgolego* rejoices in the "honour-name of *Le hoana le le nyane le tshea mang? Le tshea Kgolego Morathi.*"*

The operation, of course, is exceedingly painful, but the cries of the patient are drowned by the noise of the shouting and singing of the rest. When the operation is over the boy is led away by his warden to a spot a few yards distant, where he is hidden from view, and another victim is brought to the chair in the same way, and this procedure is repeated until every boy has been circumcised. When this done, the boys are taken away from the *Mphato* to some secluded spot in the near neighbourhood, where they are not likely to be disturbed, and here they remain quietly until towards evening. They are not allowed to touch any food all day. While some of the *Mamatsahoana* remain to guard the boys, the rest go off into the veld, or wander about the mountain side in a body, wildly singing and shouting all the time, and collecting wood for the evening fire. This is done to mislead the women and children of the kraal, and to make them believe that the whole party, including the boys, is wandering about. All through the time of the initiation rites deceptions of this nature are practised, for the men entertain the greatest horror of allowing the women-folk, and the uncircumcised, to know what is taking place. Late in the afternoon the wandering *Mamatsahoana* rejoin their companions, and then, before the sun sets, the whole party enters the *Mphato* for the first time, through the *Tsela ea Baloi.* (Plate 6, No. 2.)

A fireplace is now prepared by building two long walls of stone across the enclosure immediately against the front of the men's platform. (See Plate 6.) The wood which has been collected during the day by the wandering *Mamatsahoana* is laid in order, and fire produced by the *leshana*, or fire drill. Once the fire is lighted the flame is not allowed to die out until the rites are over, some three months later. This is made doubly sure by keeping the fire going all day immediately in front of the Chief's Seat, about the middle of the fireplace, and by appointing one of the Initiates as Keeper of the Sacred Flame. This is an important post, and the boy to whom it is assigned has to carry a burning log with him all day when the party leaves the enclosure. The fireplace is about three feet wide, and extends from near the eastern fence, close to the spot where the Hut of the Crocodile is built later on, about two-thirds of the way across the enclosure to the western gate.

The first night the boys sleep in the open on their backs,

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*See Password: Responses 57 to 60.

with their legs wide apart, and cradling their heads on their clasped hands, and are allowed to use a covering of blanket from the waist upwards. The *Mamatsahaona* are not allowed to sleep at all that night, but have to watch their wards to see that these rules are kept. Early next morning they begin to prepare sleeping sheds. The whole of the men's platform is roofed in, and a shed (Plate 6, D) divided into compartments, each holding from three to six boys, is built against the southern fence on the inside for the use of the Initiates. But this is not all done at once. The ground plan of the boys' dormitory, including the dividing walls of the cubicles, is marked out by a low wall of loose stones. Then a number of short poles, forked at the upper end, are planted in the ground. Other light poles are laid across from one support to another, and rafters are fixed across from the uprights to the outer fence of the enclosure, thus forming the framework of a long, low shed. The shed enclosing the northern part of the *Mphato* is built in a similar fashion by planting poles about five feet high in a row along the front edge of the platform, above the fireplace. Rafters run across from these to the fence at the back, forming a support for the thatched roof. (Plate 6.) The thatching is done piece-meal, a little every day. Every morning after the first day, when the morning meal has been disposed of, the Initiates and their Keepers sally forth from the *Mphato* into the veld, not returning until shortly before sunset. When they return each boy is expected to bring a bundle of wood as a contribution to the fire for the following night, but on the first few days he must also bring a bundle of thatching grass. This is collected as follows: Each Initiate provides himself with a short pole, about four or five feet long, as he goes out in the morning. During the day he collects a bundle of grass, which he ties round the head of the pole like a besom. The Chief's son, however, does not collect his own grass. When the rest of the party go out foraging he remains with the Keeper of the Sacred Fire, and contributions of grass are brought to him by the other boys. Even the tying of the bundles on to the pole is done by them. The pole he uses differs from the rest, being composed of *three* stout sticks bound together. When the party returns to the *Mphato*, these grass besoms are carried upright as far as the gate. The bundles of grass are then removed, and stacked together, and the poles stacked in another place. These poles are not used again for the same purpose; fresh ones have to be obtained every day. Late at night, after the evening meal is over, when the hymns have been sung and the dances performed, the boys go out and return each with a bundle of the grass and range themselves on the southern side of the fire. They then throw the bundles across the fire into the hands of their *Mamatsahoana*,* who stand upon the plat-

* Probably a magical rite to ensure fertility of grass.

form to receive them. These bundles of grass are used for thatching the roof of the men's platform. When this has been done, the grass which is collected by the boys every day is used for thatching their own sleeping shed.

On the fifth day after the circumcision three poles of *Mohoio* wood (a wild fig tree), which have been specially selected, are taken from the hiding place, where they have been stored for some weeks. They must be perfectly straight, without any twigs or branches throughout their whole length, and must otherwise fulfil the conditions already mentioned in connection with the gate-posts of the *Tsela ea boratatanye*. Two of these poles are fixed upright in the ground, about eight feet apart, in the open space in from of the Chief's seat. (Plate 6, No. 3.) The upper ends of the poles are notched to receive the third, which is laid across them, so as to form a "horizontal bar." This structure represents the *Tlo otshe,* or sacred elephant. (Plate 6, N. 6.) It remains in position until the *Mphato* is destroyed at the close of the ceremonies. When this sacred symbol has been erected, after the Initiates are asleep at night, one of the *Mamatsahoana* climbs up on to it, and clutching the horizontal bar with his legs, he hangs head downwards and chants "The Song of the Elephant," while the rest of the Warders join in the chorus. The *Tlo otshe* is treated with very great veneration, as it is regarded as the emblem of wisdom and the source of knowledge. All instruction in the Lodge is delivered "from the elephant" by one of the *Mamatsahoana*, specially chosen for the office, who mounts the "bar" and repeats the sacred formulæ, after assuming the dependant position described above. These formulæ are jealously guarded by the Initiated, and are committed to memory word for word, though many of the words are obsolete, and their meaning unknown. The dialectical difference between the language of the Bagananoa and that of the Bapedi is considerable, but many of the formulæ used in the Initiation rites of the Sekukuni are *identical* with those used by the people of Malaboch. A careful study of the sacred formulæ and hymns of the various Bantu "Schools" would probably be of great help to the student, who wishes to get back to the original stock language of the race.

When the "Commandments" are recited from the *Tlo otshe*, the wooden posts of the *Tsela ea boratatanye* are struck.

The food of the Initiates consists of Kaffir-corn pap (specially prepared for each boy by his female relations at the kraal), and water. The water is drawn by some half dozen or so of boys, who are told off for the task. They fetch it every day, under the care of their *Mamatsahoana*, in little calabashes, or sometimes in horns. Only two meals a day are provided—one before they leave the *Mphato* in the morning; the other after their return at night.

When the pap has been cooked at the kraal, it is heaped on to a clean dish painted white, and then formed into a long, narrow cone, surmounted by a head—the true phallic pattern—with flat, wooden spatulæ. When all are ready the girls place *dikhari* (the rings of woven grass, generally used as a support for burdens) upon their heads, and on these the white dishes of pap, and sally forth in procession, singing, to a chosen spot some distance from the *Mphato,* where a number of upright stakes are driven into the ground. When the *Mamatsahoana* hear the sound of their singing, they go out to meet them at the same spot, and after the exchange of jests of an extremely questionable nature, the youths take up the burdens and return to the *Mphato,* and deposit them outside the *Tsela ea boratatanye.* The girls deposit their *dikhari* over the stakes above-mentioned, and return home.

The *Mamatsahoana* then enter the *Mphato* singing and shouting and dancing as if nothing had happened, but at a given signal they commence whistling softly, exactly as natives do when trying to soothe or catch a startled horse. As soon as the Initiates hear this they immediately drop on one knee, and bending forward, lay their foreheads upon the palms of their right hands upon the ground, so that their eyes are covered. The *Mamatsahoana* then announce: "There is a bunch of Kaffir-corn coming for you to eat." They all reply: "We are most grateful to have *anything* to eat." The dishes of food are then brought in and placed before the Initiates. When they open their eyes and find dishes of food there, they are supposed to believe that it has been miraculously provided. Before touching it, however, the "head" of each cake must be broken off by the *Mamatsahoana,* and these heads, together with the hard skin, which always forms on Kaffir-corn pap when exposed to the air, and any other refuse of food is thrown on to the fence of the enclosure, where it will be destroyed in the last great burning.

After the first Month of Instruction, a new means of getting rid of the refuse is provided. One night, after the Initiates are asleep, a small hut, made of fig leaves, is built against the eastern fence, directly opposite the western gate. (Plate 6, No. 5.) While this is being done some of the *Mamatsahoana* are despatched to a secret cave up the mountain side to fetch the image of the Sacred Crocodile, which is hidden there. This hideous creature (Plate 7), crudely carved from a single block of wood, about six feet long, and painted white for the occasion, is safely stowed away inside this hut before they retire to rest. Early next morning the Initiates are assembled before the door of the hut, and as they prostrate themselves on the ground before it, the image is brought forth by the men, who make a hideous din, each one imitating the cry of some living animal. During the whole of

Makgolo a Dinoga.
Image of Crocodile worshipped by Bagananoa.

The "Crocodile" upon its back.

the day on which the Crocodile is revealed, a ceremonial fast is observed—*i.e.*, no food but that provided in the following way is allowed to be eaten by the *Badikana*.

A goat is provided for the occasion, by the Chief, and this is sacrificed, skinned, and disembowelled, and the remainder cooked whole. The image of the crocodile, which is hollowed out on the underside so as to form a rough trough (see Plate 7), Fig. 2) is then carried out and placed upon its back under the *Tlo otshe* and at right angles to it, with the head facing the south. Into the trough in the crocodile's body the soup or gravy from the cooked goat is poured, and a single ration of pap is added. (The pap is fetched as usual so as to awake no suspicions in the minds of those at the kraal as to what is going on, but only this one portion is used.) The *Badikana* then approach the trough on all-fours, and feed out of it like dogs; they are not allowed to touch the food with their hands. This ceremony is only performed once during the school, but the crocodile trough remains in the position between the legs of the *Tlo otshe* until the initiation rites are over, when it is returned to its hiding-place in the cave, and during the period it is used as the receptacle for all refuse of food.*

In keeping with the rest of the disciplinary system of the Circumcision Schools, the boys have to learn how to go without food for a whole day, two days, or even longer. If anything occurs which meets with the disapproval of the *Mokgota* (the Superintendent or Grand Master of the Lodge), he throws a small stone into the collection of pap in the trough, and the moment this is done all eating is stopped, and no more food may be touched for the rest of the day.

When a stranger visits the lodge, he approaches the men's gate and taps twice with his stick on the wooden posts.

The *Moswara tau* (Guardian of the Fire) answers by saying *Tsoai!* (Salt), which is a signal to all to keep silence. He then approoaches the gate and says: *Matoba* (*Rebotse*) (Tell us).

The visitor is then led round the *Mphato*, and the following dialogue, which constitutes the pass-word, which everyone initiated must know by heart, takes place:—

Moswara tau:	Visitor:
1. *Matoba!*	1. *Le mo! Le mo!*
2. ,,	2. *Lehuiti moléto.*
3. ,,	3. *La re: kgoedi tshaba.*
4. ,,	4. *Kgoedi tshaba kudu.*
5. ,,	5. *Batho rea fela.*
6. ,,	6. *Rea fela meleke.*
7. ,,	7. *Meleke melelo.*
8. ,,	8. *Melelo radisho.*

* See note, Appendix.

Moswara tau:	Visitor:
9. *Matoba!*	9. *Disho tsha ngo holo.*
10. ..	10. *Tsha hore di isoa.*
11. ..	11. *Tsha kgobokana.*
12. ..	12. *Difise khuidiri.*
13. ..	13. *Khuidisana lela.*
14. ..	14. *La ra monenyana.*
15. ..	15. *La hore le esoa.*
16. ..	16. *La tsosha kgetoa.*
17. ..	17. *Kgetoa kere tsoha.*
18. ..	18. *Bafetsoa le tshabe.*
19. ..	19. *Banna le e eme.*
20. ..	20. *Le hohe di opo.*
21. ..	21. *Di opo mathuma.*
22. ..	22. *Tsa bopea tsana.*
23. ..	23. *Tsana ratsitsana.*
24. ..	24. *Phuru muntloana.*
25. ..	25. *Pété ha barei.*
26. ..	26. *Barei bomang?*
27. ..	27. *Bo ratshetshane.*
28. ..	28. *Sebele kotshoana.*
29. ..	29. *Koto lea fotshoa.*
30. ..	30. *Le fotshetshoa kae?*
31. ..	31. *Pele le moraho.*
32. ..	32. *Moraho le tshoang.*
33. ..	33. *Le soele di batoe.*
34. ..	34. *Di batoe menoana.*
35. ..	35. *Menoana e koto.*
36. ..	36. *Eseng e koto.*
37. ..	37. *Mebedi ea Tsoho.*
38. ..	38. *Ea ho tsoara tsoara.*
39. ..	39. *E tsoere nyape.*
40. ..	40. *Nyape raphese.*
41. ..	41. *Phese se re gasoa.*
42. ..	42. *O mo hang-hang.*
43. ..	43. *Oa tsheloa metse.*
44. ..	44. *O tsene se rare.*
45. ..	45. *Se rare o polo.*
46. ..	46. *Ntsoa ramahuiti.*
47. ..	47. *Maronoa a ho to oka.*
48. ..	48. *Le motha ke tooka.*
49. ..	49. *Ke ea tooishishoa.*
50. ..	50. *Le bo seboloane.*
51. ..	51. *Le bo se bopyane.*
52. ..	52. *Ba hore ba le etshe.*
53. ..	53. *Ke eale makhereng.*
54. ..	54. *ba a lora toro.*
55. ..	55. *Toroana eo oe.*
56. ..	56. *Ekang ke le 'hu.*

MOSWARA TAU:	VISITOR:
57. *Matoba!*	57. *Lehuana le lenyane.*
58. ,,	58. *La o tshea mang?*
59. ,,	59. *Le tshea Kgolego.*
60. ,,	60. *Kgolego morathi.*
61. ,,	61. *Morathi a ratha.*
62. ,,	62. *A rathaganye metse.*
63. ,,	63. *Metse ea bomang?*
64. ,,	64. *Eabo mo ho lo he.*
65. ,,	65. *Mo ho lo ka hola.*
66. ,,	66. *Ka soaba di nanna.*
67. ,,	67. *Monyane ka hola.*
68. ,,	68. *Ka hotsha maroota.*
69. ,,	69. *Sothe matoba.*
70. ,,	70. *Polofolo noku.*
71. ,,	71. *Noku oa mosekoa.*
72. ,,	72. *Ea mpea pelo.*
73. ,,	73. *Ka mabala a aeo.*
74. ,,	74. *Marongoa rongoane.*
75. ,,	75. *A ho sega thebe.*
76. ,,	76. *Thebe di malota.*
77. ,,	77. *Malota di koma.*
78. ,,	78. *Koma di mephete.*
79. ,,	79. *Mephete me du oe.*
80. ,,	80. *Meduela tou.*
81. ,,	81. *Tou se monene.*
82. ,,	82. *Ba holo ba hona.*
83. ,,	83. *Bale bo muthe.*
84. ,,	84. *Bare ba robetshe.*
85. ,,	85. *Detsetsoana tsha mela.*
86. ,,	86. *Tsha mela temong.*
87. ,,	87. *Temong ea thoho.*
88. ,,	88. *Bale ba di itseng.*
89. ,,	89. *Bare Ke malema.*
90. ,,	90. *Sothe Matoba.*
91. ,,	91. *Monna a Matlala.*
92. ,,	92. *A tsoga boshego.*
93. ,,	93. *A opela koma.*
94. ,,	94. *Seso la mofang.*
95. ,,	95. *Ra mofa gopana.*
96. ,,	96. *Gopana ratsoai.*
97. ,,	97. *Tsoai mashishithoa.*
98. ,,	98. *Shishitoa o shalang.*
99. ,,	99. *Ra loka makoatse.*
100. ,,	100. *Sothe Matoba!*
101. ,,	101. *Sethora se toma.*
102. ,,	102. *Sethupetsha paho.*
103. ,,	103. *Eseng se tona.*
104. ,,	104. *Paho ka thupela.*

MOSWARA TAU:	VISITOR:
105. *Matoba!*	105. *Sothe Matoba!*
106. "	106. *Tsoai yane! Tsoai yane!*
107. "	107. *Ke dya madikana.*
108. "	108. *Ka ketola keto.*
109. "	109. *Keto di shalang.*
110. "	110. *Di shalela shoatshe.*
111. "	111. *Phoa!* (Spitting).
112. "	112. *Ke dilo tsha banna.*
113. "	113. *Nke di fele.*

If a stranger does not know this formula he is not admitted to the enclosure.

When the time of the initiation ceremonies is drawing to a close, the following curious custom is observed: The *Mamatshoana* collect a pot full of ashes from the sacred fire, a few handfuls of hair from the skins of different animals, and some beeswax. These ingredients are thoroughly mixed, and then formed into small cakes shaped like the excreta of the hyæna. Some of these cakes are secretly placed in the fireplace of the kraal at night, and the rest are strewn across the *Mphato* in a line from east to west.* Next morning, when the women of the kraal see these cakes they say: "A hyæna has been here during the night," and so the children are frightened, and do not wander far away from their homes. The hyæna commonly takes the place of the European bogey-man in the native homes.

The final ceremony of arraying the newly-initiated men in skins, and the return to the kraal, appears to be identical with that which will be described in a later paper on the Sekukuni rites.

APPENDIX.

Note I.—The image of the crocodile represented in Plate 6 is the one in use at the present time (1915). The original image, mentioned by Rider Haggard in his preface to "The Children of the Mist," was looted when Malaboch surrendered to the Republican forces in 1894, and may now be seen in the Transvaal Museum, Pretoria.

Note II.—The comparative study of Ethnology reveals an extraordinary similarity in the practices of uncivilized man in different parts of the world. As an illustration of this, we may take the use of the "fire drill" for producing new fire on ceremonial occasions, and the custom of never allowing a fire to die out. Among the Bagananoa these customs are observed not only during the initiation rites, but also on other occasions. The fire which burns in the *Khoro* of the Chief is extinguished

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* *Cf. Phiri*, ceremony of Sekukuni land. Also see Appendix, note 2.

when he dies, and every family fire is put out as soon as the news of his death is heard. The following day the new Chief produces a fresh flame by means of the *Leshana*, and this is never allowed to die out until it is extinguished at his death. The fires on every family hearth are re-kindled from the new Chief's fire. The same practice is followed in some or all these details by native tribes in Angola, the Congo, Uganda, and many other parts of Africa; but, what is more striking, we see the same idea existing in places as far apart as Samoa on the one side and among the people of the Natchez tribe of Indians in North America on the other. For a full discussion of the subject, giving many illustrations, ancient and modern, see Frazer: "Golden Bough: The Magic Art," 3rd edit., vol. ii, chap. xvii, etc.

The most interesting point to be observed in these customs, however, is to be found in the apparent resemblance to some ancient rites which became crystallized in the Egyptian Ritual, and which are recorded in "The Book of the Dead." Dr. Churchward, in "Signs and Symbols of Primordial Man," draws attention to the widespread practice of a rite which represents in symbol the ancient legend of Sut and Horus.

So far I have not been able to get any evidence as clear as that of the Wellunqua ceremony practised by the Warramunga tribe in Australia,* but there are many points of contact in the rites I have described in the foregoing pages, and if it can be proved that these esoteric rites are derived from some ancient common source, the value of the careful study of the customs of the Bantu will be evident to everybody.

The legend of Sut and Horus was this: Sut was the God of Darkness; Horus was the God of Light. Sut was the supreme deity till Horus came on the scene, when a fierce battle ensued, and the God of Darkness was overcome. Being hard pressed, Sut transformed himself into a snake and disappeared into a hole in the earth. In order to keep him there, Horus placed a magic pole with his own hand upon it over the spot.

It appears that wherever traces of this myth are found, there will be seen the emblem of the snake, the hole into which it disappeared, and the footsteps (of the pursuing Horus?).

Sut, and consequently the serpent, was regarded as the Spirit of Evil. From a careful study of the Bantu folk-lore, we find that among the tribes of the Northern Transvaal the hyaena, and not the snake, is regarded as the embodiment of evil. This gives us a starting point. The Bapedi custom of laying the *spoor* of the hyæna round the *Mphato* is singularly reminiscent of the *spoor* of the man described elsewhere.

Further, the image of the crocodile worshipped by the Bagananoa is called "The father (or grandmother) of the Snake." It is taken from its retreat in the bowels of the earth

* Spencer & Gillen, "The Northern Tribes of Central Australia."

and worshipped, but is then *turned upon its back*, and kept in that position under the *Tlo otshe*—the source of knowledge and light! Is not this symbolic imagery of the victory of Horus?

It must be confessed that the evidence adduced above is very slender, and based largely on surmise, but the existence of so many well-known legends and beliefs (*e.g.*, the snake spirits that are supposed to haunt rivers, the widespread belief that snakes become the "hosts" of departed human spirits, etc.), which may be relics of an older serpent worship, has led the writer to add this note in the hope that it will lead to further and more careful study of our native customs in all their details.

Note.—The writer is very grateful to Miss Wilman, of the McGregor Museum, Kimberley, for drawing his attention to a rude intaglio on the rocks at Metseng, which evidently represents the snake, hole, and footsteps of the Sut and Horus legend.

FOOD VALUE OF KAFFIR CORN.—Three samples of Kaffir corn have been recently investigated in the laboratories of the Imperial Institute, and found to be very similar in composition and value to Indian "dari."* A few years ago an article on "The utilisation of Sudan Dura" was published by the Imperial Institute,† and it is now stated that for all uses of the Sudan dura referred to in that article, the South African Kaffir corn would be equally suitable. The following comparative analytical results are recorded in this connection:—

	Kaffir Corn.			White Dura: Sudan.	Red Sorghum: Zanzibar.	Indian. Dari.
	White. Per cent.	Red. Per cent.	Mixed. Per cent.	Per cent.	Per cent.	Per cent.
Moisture	11.93	12.00	11.73	8.45	10.0	12.5
Crude protein ..	9.79	10.83	10.01	13.06	11.2	9.3
Fat	3.22	3.37	3.06	3.30	2.8	2.0
Starch, etc.	72.50	71.01	72.58	72.45	72.1	72.3
Fibre..	1.27	1.28	1.14	1.03	1.8	2.2
Ash	1.29	1.51	1.48	1.71	2.1	1.7
Nutrient ratio ..	1:8.2	1:7.3	1:8	1:6.1	1:7	1:8.25
Food units	105.0	106.5	105.2	113.3	107	101

* *Imp. Inst. Bull.* (1915), **13**, 379, 380.
† *Imp. Inst. Bull.* (1913), **11**, 33.

A CRITICISM OF LOTSY'S THEORY OF EVOLUTION.

By Prof. SELMAR SCHÖNLAND, M.A., PH.D., F.L.S., C.M.Z.S.

The enormous amount of work which has been done on the theory of evolution since the publication of Darwin's "Origin of Species, in 1861, leaves one with a feeling of disappointment. It cannot be denied that the facts which have been accumulated during the last 50 years have made it quite plain that evolution has taken place in the organic world, but hardly two biologists agree exactly as to the means how it has been brought about.

Both Darwin and Wallace were of opinion that the origin of new species (into which evolution ultimately resolves itself) was due to natural selection in the struggle for existence. We need not cavil at the term "natural selection," which even Darwin, in chapter IV of the "Origin of Species," considers a false term, if literally taken. Those who do not like it may substitute "natural elimination" for it, as Professor Lloyd Morgan did.

Both Darwin and Wallace started from the fact that the individuals of each species are not exactly alike, that they, as it were, oscillate round a type, and that the fittest will survive. Asa Gray said* in 1880 (in a lecture before the Theological School of Yale College):

> Natural selection by itself is not a hypothesis, nor even a theory. It is a truth—a *catena* of facts and direct inferences from facts. . . . There is no doubt that natural selection operates; the open question is, what do its operations amount to?

He clearly saw that natural selection does not go to the root of the matter. In his "Evolutionary Teleology" he states:

> Natural selection is not the wind which propels the vessel, but the rudder which, by friction, now on this side and now on that, shapes the course. The rudder acts while the vessel is in motion, effects nothing when it is at rest. Variation answers to the wind. . . . Its course is controlled by natural selection. This proceeds mainly through outward influence. But we are more and more convinced that variation . . . . is not a product of, but a response to, the action of environment. Variations are evidently not from without, but from within.

Even Darwin himself has explicitly stated that natural selection has been the most important, but not the exclusive, means of modification. There have been many who have followed Wallace in ascribing to natural selection exclusively the power of bringing about evolution. Amongst them was Weismann, who, by his theory of Amphimixis, tried to remove an obvious difficulty presented by the undoubted great stability of specific types even if taken in the Linnean sense. The fundamental question, how new variations arise, is hardly touched if we substitute Lamarckism† for Darwinism, or even if we accept

* Sereno Watson in "Memorial of Asa Gray." Cambridge University Press. 1888. p. 42.

† Compare Herbert Spencer, "The Inadequacy of Natural Selection," in *Contemporary Review*, February, March, and May, 1893.

De Vries' mutation theory, and in both theories the theory of natural selection is required, at all events as a subsidiary theory. Darwin tried to get an idea how external influences may cause variations by means of his "formal" theory of pangenesis, while De Vries, objecting to the direct influence of external circumstances, tried to explain variation by his theory of intra-cellular pangenesis." During recent years the question of the origin of species has been brought into a new path by the re-discovery of Mendel's laws, which fitted in with many of Weismann's speculations, and also with De Vries' theory of pangenesis. Thus, in his very first publication on Mendelism, "Das Spaltungsgesctz der Bastarde" (*Vorläufige Mittheilung*), De Vries states at the beginning:*

> According to pangenesis, the whole character of a plant is composed of definite units. These so-called elements of the species or elementary characters are imagined to be connected with material bearers. There are no transitions between these elements, just as little as there are none between the molecules of chemistry.

It seems that this view can hardly be maintained any longer. Thus Bateson states:†

> Some of my Mendelian colleagues have spoken of genetic factors as permanent and indestructible. Relative permanence in a sense they have, for they commonly come out unchanged after segregation. But I am satisfied that they may occasionally undergo a quantitative disintegration.

But if I understand this rightly, it means that they may disappear altogether, and such characters as, *e.g.*, hairiness and smoothness of plants, will pass into one another, and natural selection will have to come in not only with these characters, but also with correlated characters.‡ Bateson does not speculate on the evolution of species.

> The thought uppermost in his mind is that knowledge of the nature of life is too slender to warrant speculation on these fundamental subjects.

But the sentences which I have quoted above seem to me to show that he overstates the case when he tells us§ that

> Jordan was perfectly right. The true breeding form which he distinguished in such multitudes are real entities, though the great systematists dispensing with them have pooled them into arbitrary Linnean species for the convenience of collectors and for the simplification of catalogues.

On the same page he says:

> Lotsy has lately with great courage suggested to us that all variation may be due to crossing.‖ I do not disguise my sympathy with this

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* *Ber. der deutsch. bot. Ges.* (1900), 83.

† Rept. Brit. Assn. for Adv. of Sc., Australia (1914), 16.

‡ For instance, in certain species of *Cotyledon*, as in *C. orbiculata* L. the nectar chamber is closed by tufts of hairs on the filaments, in others closely allied in all other characters as, *e.g.*, in *C. velutina* Hook f. the hairs are gone, but the filaments are broadened at the base, and perform the same function.

§ Op. cit. 15.

‖ Lotsy states plainly that Kerner was the first to suggest that new species arise through crossing, and he shows how far his conceptions differ from those of Kerner.

effort. . . . After the blind complacency of conventional evolutionists it is refreshing to meet so frank an acknowledgment of the hardness of the problem. Lotsy's utterance will at least do something to expose the artificiality of systematic Zoology and Botany.

The poor hard-working systematists might well, after these complacent words throw up the sponge in despair, but it may be just as well to examine Lotsy's theory for ourselves, and see whether it can influence us in our future work.

Lotsy starts from the assumption that evolution is possible if species are constant, and that crossing is the means by which it is brought about.* It appears to me, however, strange that he based his theoretical views on the results of crossing *Linnean* species of the genus *Antirrhinum*—which, if I understand him rightly, are heterozygotes—and consequently the very arguments which he uses to demolish De Vries' mutation theory† can be urged against his. However, we shall let that pass.

Lotsy defines his position in the concluding paragraph of his paper‡ as follows:

Briefly stated, I mean that a species, a hymozygote combination, is constant *ad infinitum,* that it reproduces itself until its reproductive cells become combined with those of another homozygote (or heterozygote), and thus an exchange of "genes" becomes possible.

On the preceding page he says:

I am thus of opinion that at the present time, apart, perhaps, from loss-mutants,§ only one kind of formation of new species has been proved, namely, new combinations by crossing of "genes" which were already present in the parents, and that a homozygote modification, namely, a pure species, is constant, apart from non-transmissible modifications caused by external circumstances.

From this follows—

1. All differences between the individuals of a species are non-transmissible modifications.
2. There are (perhaps with the exception of loss-mutants) no hereditary mutations or sports within a pure species. All that has been described as such is the result of the splitting (vegetative or generative) of heterozygote combinations.
3. A transmission of acquired characters is impossible.
4. All "genes" (*Anlagen*) present in higher organisms were present already in the totality of primitive organisms (*Urorganismen*).‖

This does not necessarily mean that there ever was *one* primitive organism with all these "genes"; on the contrary, it appears to me probable that each primitive organism possessed only few "genes," and it is just this small number of "genes" which I consider to be the cause of their very limited powers of development, and I am confirmed in this view by the fact that all living beings which reproduce themselves only asexually have comparatively simple structure.

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* "Fortschritte unserer Auschauungen über Descendenz seit Darwin und der jetzige Standpunkt der Frage": J. P. Lotsy in "Progressus Rei Botanicæ," **4** (1913), 378.

† Op. cit. 372.

‡ Op. cit. 388.

§ Caused by the loss of one genetic factor from a gamete.

‖ The question how these *Urorganismen* acquire their "genes" is not discussed by Lotsy, and perhaps wisely so, because he would then have had to show that the very difficulty which he fails to overcome as regards higher organisms confronts us in the lowest, if Lotsy's views are correct.

Only sexual reproduction, that is, crossing, brought together the "genes" of different primitive organisms, and thus created the basis for higher development and progressive formation of species.

It will be seen from these statements that Lotsy means by his species the so-called "petites éspèces" of Jordan.* I have already on a previous occasion pointed out that it is not advisable to retain the names "species" for these units, since the term ordinarily is used in a much wider sense. They should rather be called Jordan's units, and the term "species" should be used in the usual sense.

Lotsy's theory to a certain extent resembles Nägeli's orthogenesis. Given certain primitive organisms, and a thorough knowledge of them, and the trunk and tusks of an elephant can be predicted from them with mathematical necessity provided the circumstances permit of their formation; with the same necessity arise the brain of man, the stinging hairs of nettles, the tendrils of the vine, and millions of other developed *Anlagen,* Stated in this almost brutal nakedness, the theory appears absurd at sight. That my way of putting it is not unjustified follows from Lotsy's own words. Thus, on page 371 he writes:

The "gene" (*Anlage*) for legs can, *e.g.*, very well have been present already in an evertebrate animal, but has only been able to come into effect after it had come by crossing into an organism with the "gene" of a vertebral column. This organism can either have had formed already the vertebral column or may still be evertebrate when it was still without the "gene" on which the "gene"' for a vertebral column has to act. Thus, both "genes," that for a vertebral column and that for legs, may be present in an evertebrate animal.

In other words, according to this theory, the "genes" for legs and vertebræ may already be in amœbas. This is more easily asserted than disproved, but to my mind nothing wilder was ever propounded by the exponents of the much-ridiculed German *Naturphilosophie* of about a hundred years ago. On the one hand the primitive organisms are supposed to be so very simple; on the other hand they are supposed to contain already certain peculiarities (by whatever term we may designate them), which include the germs of the countless specific characters of higher plants and higher animals

At the same time, I do not at all agree with the view that the simplest organisms are as simple as they are usually represented. In fact, having followed carefully the recent discussion of the possibility of creating artificially living beings, I was simply amazed at the fact that prominent men lead their authority to the belief that this may be possible. Haagedorn,† at all events, expresses this very cautiously as follows:

I do not think the possibility is excluded of creating "living" organisms by a combination of not-living things, like the "filterable viruses"

* Or, more strictly speaking, Johannsen's pure lines.

† "Vorträge und Aufsätze über Entwicklungsmechanik der Organismen herausgegeben von Roux," Heft 12.

and other autocatalytical substances, in thus choosing them to create a system of structural relations, and thus a "body" for the combination.*

He points out that one can, *e.g.*, separate by filtration the active substance of the tetanus bacillus and of the yeast plant, and that these essential parts of the bacteria and yeast cells are combined in these organisms by surface-tensions and other forces to form the specific organism, while through pressing they have lost this form. I am afraid I cannot follow this reasoning. If I remove the motorcars from a motorcar factory, I get some idea of its activity; but without having seen such a factory I have no idea how the building and the machinery it contains are constructed, and how a motorcar is manufactured, and no amount of motorcars put together will make a motorcar factory; and the same applies if in the same factory other vehicles or tools are also made. In other words, the substances produced by cells do not give us any idea of the ultimate structure of their vital parts, the protoplasm; and while one may even admit that the metabolic activities of protoplasm are carried on largely by catalytical substances, this does not mean that we have any insight into the structure of protoplasm which manufactures them, and how, *e.g.*, it can react to stimuli, how the protoplasm of different parts of the same organism reacts in opposite directions to the same stimulus, how it can change its reactions, and so on.

Lotsy, believing in the constancy of homozygotes, naturally asked the question how this belief can be harmonised with a belief in the evolution of species. The answer is, according to him, as mentioned above, indicated in crossing of different Linnean species of *Antirrhinum*. He showed with Baur that these possess segregating Mendelian characters which hitherto were supposed to be restricted to varieties, and by crossing these, there arise, sooner or later, sometimes in F_2, some homozygote combinations, thereore *new species*. It seems to me, however, doubtful whether—

(1) The result of his experiments can only bear the interpretation which he ascribed to it;

(2) They can prove that species may not arise by other methods.

In view of Mendelian segregation and combination of characters, it is generally assumed that the chromosomes during mitosis bear definite hereditary tendencies. This may be conceded; but when these tendencies are pictured as something tangible, something which is, as it were, bodily included in the nuclear substance—something that, if our methods were refined enough, could be separated and perhaps injected into other organisms with the result of giving them additional properties, then I cannot accept the view. We know (*e.g.*, in *Polysiphonis, dictyota*) that haploid individuals may have the same external

* As quoted by Lotsy, p. 386.

characters as diploid individuals of the same species. We know that diploid prothalli of ferns may produce ripe sexual organs (even motile spermatozoids with the usual chemotactic reactions). The majority of hereditary tendencies may, therefore, be carried by half the number of chromosomes, and different sets of characters may be carried if the full number of chromosomes is present. As far as we can tell, the nuclei in the second case mentioned are sporophyte-nuclei, yet something must have happened to them to make the production of the prothallus possible, although it is a prothallus in which sexual reproduction is impossible. To my mind the assumption of an internal rearrangement of the essential components of the protoplasm is sufficient to make these facts intelligible, however far from an explanation this may be. The advantage of Lotsy's view, according to him,* consists in creating an analogy between the living and non-living world. He says:

> Roughly speaking, the "genes" correspond to the elements, the constant species to the constant compounds; and just as the constant compounds can only form with one another new compounds if separating their elements, so also the constant species can only form new species if in reproduction the system of "genes" fall apart, and with other disintegrating systems of "genes" (*Genencomplexe*) form new compounds of "genes" which represent new constant species in so far as they are or become homozygous.

However, I venture to think that if the analogy is closely examined, it does not bear out Lotsy's contention, and yet if it could be strictly insisted upon, it would bring certain facts into stronger light. If a disaccharide is hydrolised, and by addition of water two molecules of hexoses are formed, no separation into the elements takes place. Moreover, the properties of the elements as such bear no direct relation to the properties of the compound from which we started, and the compounds at which we arrive, and yet the compounds amongst themselves are what we might call different species of the same genus. This point need not be laboured further. It can be illustrated by innumerable similar facts taken from organic chemistry. Now, if we assume that the protoplasm of a species is composed of a definite chemical compound or a series of them united in a hitherto not understood manner, we arrive at the notion of constant species, or, to put it more precisely, of relatively constant species, and I do not see any difficulty in explaining with this assumption the existence of Jordan's units and of species in the ordinary sense. The protoplasm, as stated before, must be something different from the enzymes to which nowadays most of the vital activities of plants and animals are ascribed. In plants glucosides and appropriate enzymes do not exist in the same cells, so normally there is no decomposition. They are brought together should the cellular structure be damaged, and in some instances during germination.

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* Op cit. 383.

It has been shown by H. E. and E. F. Armstrong that a variety of substances, having the property in common that they have but little affinity for water, are able to penetrate the walls of certain plant cells. As a consequence, alterations in equilibrium are set up within the cell, and changes are induced which involve alteration of the concentration and the liberation of hydrolytic enzymes. The general name hormone has been applied to the substances active in this manner; it has been shown that the group includes not only carbon dioxide, but materials such as hydrogen cyanide, hydrocarbons, alcohols, esters, aldehydes, mustard oils, etc., all of which are normal products of plant glucosides. . . .The materials so formed will be active *in still further stimulating change.**

One cannot help admiring these and so many other marvellous results which workers in biochemistry have achieved during recent years, yet one cannot get away from the impression that, instead of getting us nearer the understanding of the basis of life, they have opened our eyes to our utter ignorance of it. There is not the faintest indication of any fact that helps us to understand irritability. There is no indication of any explanation of specific characters. There is nothing in them that gives us a hint as to how evolution is brought about. There is nothing to give us any idea how we can picture to ourselves the pangenes of Darwin, De Vries, or Lotsy, and I am afraid that Lotsy's theory has not brought us a step further in our search for a *vera causa* of evolution. I thoroughly agree, however, with Lotsy that species are not mere shifting phantoms, but definite entities. I have on a previous occasion† pointed out that while one can speak of species as constant, this does not exclude that they exhibit a wide range in fluctuations or, as they are usually called, variations.

The basidiomycetes appear to me to furnish convincing proof that species formation is not always due to the exclusion of "genes," or, in other words, to loss-mutants. The nuclear fusions known amongst them, which may be equivalent to sexual reproduction, take place between nuclei that must in each case ultimately have been derived from one and the same nucleus. Provided that only previously existing "genes" are available, formation of new species could, indeed, only proceed by the loss of "genes." Nobody will suggest that the simple basidiomycetes have been derived from the most highly differentiated ones; on the contrary, these evidently stand at the end of the series of development in this group. According to Lotsy, we must then assume that the characters of these (*e.g.*, of *Phallus*) were hidden in the simpler ones, but they cannot have become apparent by the shuffling of the "genes" of the simpler ones, as crossing between different species is impossible so far as our experience goes. They must have been hidden in single species, which, to say the least, is not likely. In many of the parasitic basidiomycetes, moreover, we are well-acquainted with so-called physiological races, some of which are easily produced. Their

* E. F. Armstrong, "The Simple Carbohydrates and the Glucosides," 2nd ed. Longmans, Green & Co. (1912), 127.

†Rept. S.A. Assn. for Adv. of Sc., Grahamstown (1908), 148.

differences can only be explained by the assumption of slight differences in the composition of their protoplasm, and I think it is not far-fetched to assume that such physiological races may form the material on which natural selection can act in the production of new species.

The almost incredible persistency of species through vast geological ages and the enormous present distribution are proofs that we cannot look upon species as mere creations of systematists. I have referred to a few striking examples in my paper just quoted, and I will refer here only to one case which I have recently studied with the aid of an almost overpowering mass of material. *Crassula muscosa* (L.) Roth (= *Tillœa muscosa* L.) is a well-known annual first described from Central Europe. A large number of allied species were described from the countries round the Mediterranean, Persia, India, Tropical Africa, South Africa, Australia, New Zealand, Tasmania, South America, and a small part of North America. A most careful study of thousands of specimens has convinced me that they all belong to one species. Some specimens from Europe agree exactly with some from South Africa, except that they differ in the number of floral parts (a common variation in many Crassulas), yet the typical form is absent from Tropical Africa, India, and Australia. There are a number of ferns which grade into one another, and there are, lastly, some from India, Tropical and South Africa which stand by themselves, being perennials (one with a tuberous root), which I shall for convenience' sake treat of separately. Now here are thousands of specimens from different parts of the world sticking persistently to a number of easily recognisable characters. Is it not reasonable to suppose that they all had a common origin? Is it not reasonable to give them a common name, and note simply the characters in which they vary? There is no fact known to me that its wide variations might be due to crossing. To my mind the "seed-pan botanists," however valuable their work has been, are apt to rather over-estimate their work and obscure the issue. They seem quite to forget that the term "species" denotes an entity in a logical sense only, and that it is just as easy to defend the assertion that there is no such thing as an individual as to say that there are no species except so-called "homozygotes."

But to come back to Lotsy's theory. As stated above, I miss in his paper any reference to the countless number of fungi in which crossing is impossible. How have such species arisen? Lotsy's theory cannot supply the answer, and, if it is thought to be generally applicable, it must fall, unless such cases are satisfactorily explained.

It seems to me also that, if it were generally applicable, it should show itself in two facts.

Firstly, the genera with the most numerous species should

be those in which the species most easily hybridise. I doubt whether this is so, although the European flora seems to afford good examples to make this supposition probable.

Secondly, genera in which cross-breeding in a state of nature is of frequent occurrence should show few well-defined species. It is, *e.g.,* a well-known fact that one cannot breed aloes true in South Africa or in countries where they can be grown in the open, when you have a number of species close together and natural hybrids are also common, yet a large number of species which grow under conditions where hybridisation is possible have, to our certain knowledge, persisted as far as our knowledge of them goes back. The same applies to Stapelias. I have purposely refrained from touching on zoological evidence that may be brought forward against Lotsy's theory. But I think I have said enough to show that while I am far from asserting that hybridisation may not be one of the factors which have brought about evolution, I cannot admit that Lotsy's theory has brought us nearer the knowledge of the *vera causa* of evolution. This is still, as S. Laing would have said, A PROBLEM OF THE FUTURE.*

DROUGHT IN THE WATERBERG.—The Annual Report of the Smithsonian Institution, Washington City, U.S.A., for 1914, just received, contains, by special permission, a reprint, *in extenso,* of an article by Adv. E. N. Marais, of Rietfontein, Waterberg, taken over from the *Agricultural Journal of the Union of South Africa,*" and entitled "Notes on some effects of extreme drought in Waterberg, South Africa."

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* The very interesting ovarial treatment of *Scrophularia* by McDougal with a dilute solution of potassium iodide which yielded two aberrant individuals deserves great attention in connection with the matter under discussion, especially as evidence has been produced by F. E. Lloyd that the reagent penetrates to the egg-apparatus. It is too early yet to base and definite conclusions on the results, though carried already to the F_2 generation. However, the changes produced are not premutational or cumulative, but are induced by direct physico-chemical action. They seem to show that "some departures might be evaluated as losses of characters, others are increased differentiations," which of course Lotsy would explain as more or less dormant "genes" let loose.

See "Yearbook of the Carnegie Institution of Washington," **13** (1914), 77-81.

THE MEASUREMENT OF THE NATURAL IONISATION OF THE AIR.

By EDOUARD JACOT, B.A.

Various types of apparatus have been designed for observations on the natural ionisation of the air. Elster and Geitel, who were the first to attempt such observations, used a very simple form of apparatus. A charged conductor, carefully insulated, was exposed in the open air and connected to an electroscope. The rate at which the conductor lost its charge was taken as a measure of the state of ionisation of the air near the conductor. The apparatus is still used, but the results have little useful meaning. Meteorological conditions have an important influence on the measurements. The presence of dust, or moisture, or wind of any kind, seriously affects the observations. Thus, the ionisation measured in fog or a dusty atmosphere is unnaturally small, as there is necessarily an unnaturally rapid rate of recombination between ions when particles suitable for nucleation are distributed in the atmosphere.

Other methods of measuring the ionisation have since been devised. The Gerdien and the Ebert forms of apparatus are the best known. The principle of both is essentially the same.

The Gerdien consists of a central horizontal metal cylinder, some 25 cms. long and 1.5 cms. in diameter, mounted within a large cylinder 56 cms. long and 16 cms. in diameter. The inner cylinder is connected to an electroscope and insulated from the outer, which is earthed. A current of air is drawn through the apparatus by means of a fan; and, the inner cylinder having been charged, the rate at which the electroscope leaves collapse is noted. The conductivity of the air can then be calculated.

Gerdien's expression for the conductivity is as follows:—

$$\frac{C}{T}\, log_e \frac{V_1}{V_2} = 4\,\pi\, nev \left(\frac{l}{2\, log_e \frac{r_0}{r_i}} \right)$$

r_0 and r_i are the radii of the outer and inner cylinders respectively; l the length of the inner; C is the capacity of the inner cylinder and the electroscope; n is the number of ions per c.c. of air, positive or negative, according to the charge of the inner cylinder; and v is the mobility of these ions; e is the electronic charge. If the potential of the inner electrode falls from V_1 to V_2 in a time τ, the expression gives the quantity nev, the conductivity of the air. If the inner electrode is initially charged positively, the quantities n, e, v would refer to negative ions; and *vice versa*.

For practical use, Gerdien's expression is incorrect. The expression $\dfrac{l}{2\ \log_e \dfrac{r_o}{r_i}}$, which is, of course, a theoretical expression for the capacity of a simple concentric cylinder condenser, cannot be used in this instance. The point is important; for results obtained with the help of Gerdien's formula have been found to differ by as much as 40 per cent. from results given by the amended formula:

$$\frac{C}{T}\ \log_e \frac{V_1}{V_2} = 4\ \pi\ nev\ K$$

where K is the measured capacity of the system made up of (1) the outer cylinder; (2) the inner cylinder; and (3) the thin support to the inner cylinder which connects it to the electroscope, and is necessarily itself exposed in part to the air current.

The Ebert form of apparatus is much the same in principle as the Gerdien, but is more self-contained. The concentric cylinders are vertical. The radius of the outer is of the order of 2 cms. instead of 8, and the inner cylinder is fitted directly to the leaf system of the electroscope. Air is again drawn between the cylinders by a turbine actuated by clockwork, the number of c.c. passed per second being automatically recorded by a calibrated andlemometer. Various observations allow of the quantities n, v, and nev being separately calculated.

Observations with the Ebert apparatus are tedious, and unless the ionisation is abnormally great, cannot be conducted quickly. This is an important disadvantage, as the state of ionisation of the air, except under peculiarly favourable conditions, varies continuously. With the Gerdien apparatus, on the other hand, the necessary observations for the calculation of the conductivity can be made in a few minutes.

Both the Gerdien and the Ebert types of apparatus have come into general use, and, rather unfortunately, both are often accepted as standard instruments.

The writer has made observations in the open air at the South African College with both instruments. The observations were made in the most favourable weather conditions. The instruments were set up near one another, and measurements with each were made simultaneously.

Values of the conductivity nev as given by either instrument were found to be reasonably consistent. But there was never any agreement between any one value as given by the Gerdien and the corresponding value as given by the Ebert. Thus, the conductivity measured by the Gerdien was found to be *consistently* of the order of 10^{-5}, the conductivity contributed by the positive ions being generally in excess of that contributed by the negative ions. On the other hand, the conductivity measured

by the Ebert was *always* less than 10^{-5}; values given by the Gerdien being sometimes as much as 50 times greater than corresponding values given by the Ebert.

We conclude that each instrument measured some definite quantity, but that the meaning of the quantity differed in the two cases. We proceed to an examination of the exact meaning of these quantities.

The ions present in air at any time are of different kinds. The simplest types are ions which have about the same mobility as the ions produced in dust-free air by ordinary ionising agents, such as the rays from radio-active substances. Ions of this kind carry a simple charge e, and have a mobility of 1.0 to 1.8 cms. per second per volt per cm. A second type of ion is the Langevin ion, very complex in structure and of low mobility, varying from .0008 to .0003 cm. per second. The nature of this ion is imperfectly understood. Pollock has recently advanced the view, based on a thermodynamic argument, that it is a complex ion carrying absorbed moisture in the liquid state. The ion does not exist in dust-free air; so that the nucleus is probably a dust particle. In addition to these two types of ions, a class of ion intermediate in size and mobility is now recognised. Pollock argues that these ions are surrounded by an envelope of water vapour. Their mobility varies between .07 and .007 cm. per sec. The number of these three types per c.c. varies. Pollock, at Sydney, found that the number of small ions of any sign varied from 0 to 160; the number of intermediate ions from 200 to 1,000; while the number of Langevin ions varied between 600 and 5,500. At the Cape, as will be seen later, the number of small ions probably never falls to zero; and the total number of small and intermediate ions is certainly always greater than the corresponding average number given by Pollock.

Now the conductivity nev of the air, as it appears in the expressions of Gerdien and Ebert, involves n, the number of ions of any one sign per c.c., and v, the mobility of these ions. But since v is not a constant quantity, and since n is made up of different numbers of different ions, the conductivity could be better expressed as $\Sigma\ nev$—the summation to include all types of ions and all mobilities; and any instrument, if it is to fulfil a useful function, should measure either this total conductivity or any one of the terms nev which make up this total conductivity—that is, the instrument should be designed to catch all ions, or some definite type of ion only.

The two forms of apparatus under discussion do neither; and, further, the quantity actually measured by the one apparatus is not the quantity measured by the other. Ions caught by the Ebert apparatus are not the same in number or in kind as are those caught by the Gerdien apparatus, and, in consequence, the average conductivity as determined from results obtained with the one cannot agree with the corresponding quantity obtained

from the other. The following consideration shows this clearly:—

The equation to the path of an ion at a distance r from the common axis of two concentric cylinders of the Ebert or Gerdien type is:

Where U is the velocity of the air stream parallel to the axis of

$$\frac{dr}{dx} = \frac{Ev}{U}$$

the cylinders, *i.e.*, the x axis;
and E is the electric intensity at a point distant r from the axis, and acting at right angles to the axis.

If Q is the charge on the inner electrode, and l is the length of this electrode,

$$E = \frac{4 \pi Q}{2 \pi r l}$$

Hence $$\frac{4 \pi v Q}{l} dx = 2 \pi r U dr.$$

If a is the radius of the innter electrode, and b is the inside radius of the outer cylinder, an ion initially at a distance $r=b$ from the axis will be caught by the inner electrode after travelling a distance x parallel to the axis, where x is given by

$$x = \frac{l V}{4 \pi v Q} \int_a^b 2 \pi r \, dr.$$

$$= \frac{l V}{4 \pi v Q} [\pi b^2 - \pi a^2]$$

$$= \frac{l N}{4 \pi v Q}$$

where N is written for the quantity of air drawn from between the cylinders per second.

Hence all ions of mobility v which enter the space between the outer and inner cylinders will be caught by the central electrode, provided l is made just greater than x;

i.e., $$l > \frac{l N}{4 \pi v Q}$$

or $$\frac{C V}{N} > \frac{1}{4 \pi v}$$

where C is the capacity of the innter and outer cylinders, and V the potential to which the inner is charged.

Hence, if an inner electrode is to collect all small ions—that is, ions of average mobility, 1.5 cms. per sec. per volt per cm.—the condition to be satisfied is:

$$\frac{C\,V}{N} > \frac{1}{4\,\pi \times 1\,5.}\,\frac{1}{300}$$

or $$\frac{C\,V}{N} > \cdot 00018.$$

(C and V are here expressed in electrostatic units, N is measured in c.c. per sec.; and v is therefore reduced to cms. per sec. per electrostatic unit per cdl.m.)

Similarly, if the apparatus is to collect all ions of the second class, *i.e.*, ions of average mobility, .038 cm. per sec. per volt per cm.,

$$\frac{C\,V}{N} > \frac{1}{4\,\pi \times \cdot 038}\,\frac{1}{300}$$

or $$\frac{C\,V}{N} > 007.$$

And if the ions collected are to include the Langevin ions,

$$\frac{C\,V}{N} > \frac{1}{4\,\pi \times \cdot 00055}\,\frac{1}{300}$$

or $$\frac{C\,V}{N} > \cdot 48.$$

Now, in the case of the Ebert apparatus, C is 17 cms.; V is of the order of $\frac{200}{300}$ electrostatic units, and an average value for N is 1,150 c.c. per sec. This gives for $\frac{C\,V}{N}$ a value .0095.

In the case of the Gerdien apparatus $\frac{C\,V}{N}$ is about .22.

A comparison between these numbers and those derived above shows that results obtained with the two instruments are not comparable. For whereas the Gerdien type of instrument must collect some Langevin ions in addition to all others, the Ebert certainly does not.

The Ebert apparently collects all the small ions and all ions of the second or intermediate class. Values obtained with the Ebert for the number of ions per c.c. and their average mobility otherwise confirm this. During a series of observations the number of positive ions per c.c. varied between 1,134 and 1,800; and the corresponding numbers for the negative ions between 1,157 and 1,681. The ratio of the number of positive to the number of negative ions varied between the limits 1.08 and 1.02, and was therefore fairly constant. The values of the mobilities of ions of either sign varied between .058 and .736. Also, when the number of ions per c.c. was small, the mobility was high; while the mobility diminished as the number of ions increased. Now .058 and .736, the limits for the observed mobilities, are values intermediate between .038 and 1.5, the

average mobilities of the first and second class of ion respectively. Hence, during the actual observations both these types of ion must have been present. Thus an average mobility of .058 would indicate the presence of a large number of the larger of these ions and only a few small ions. An average mobility of .730, on the other hand, would suggest an important diminution in the number of the larger ions, and hence a diminution in the total number of ions per c.c. We should therefore expect to find associated with low average mobilities high values for the total number of ions, and *vice versa*.

If the Gerdien and Ebert instruments are to give results that are at all comparable, the quantity $\frac{C\ V}{N}$ derived above must be chosen of the same order for both. With the present designs of apparatus this is almost impracticable. Thus, in the case of the Gerdien the value of $\frac{C\ V}{N}$ could be made to approximate to that for the Ebert by reducing V and increasing N. The design of the Gerdien electroscope, however, does not admit of any important reduction of V, while the large dimensions of the outer cylinder make it difficult to increase N beyond 100 c.c. per sec. On the other hand, a decrease in N in the case of the Ebert is not convenient; while the range over which V can be varied is again limited. I have brought the quantity $\frac{C\ V}{N}$ for the Ebert apparatus nearer the corresponding quantity for the Gerdien by increasing the capacity of the Ebert with the help of a parallel plate air condenser; and values given by the instrument so modified certainly approach those given by the Gerdien. Unfortunately, the increased capacity of the Ebert, reducing as it must the rate of leak of the electroscope, has the effect of greatly, and probably prejudicially, extending the time required for making the necessary observations.

Soluble Phosphates.—Prof. W. Bottomley has patented a novel process for the manufacture of soluble phosphates for fertilising the soil. The specification claims the manufacture of soluble phosphate from mineral phosphate by mixing the finely sub-divided phosphate with a small proportion of a suitable food for micro-organisms, and with aerobic organisms from putrefying organic matter, and maintaining the mixture at a temperature considerably above the normal. It is also claimed that the soluble phosphate may be produced from mineral phosphate by moistening the latter, after having been finely subdivided, with a putrefying liquor, and maintaining the mass at about 30 degrees Centigrade for about a week.

THE OSTRICH FEATHER INDUSTRY IN SOUTH AFRICA.

By Russel William Thornton.

Historical.—The Ostrich is mentioned, and one may even say described, in the Bible, so that there is little doubt that a great deal was known about this bird for many centuries before domestication took place in South Africa. Ancient Egyptian inscriptions and accounts by Greeks and Romans show the antiquity of this species. In the reply of the Lord to Job, the habits of the Ostrich are as clearly described as we might describe them to-day.

Distribution.—The geographical range of the Ostrich was very extensive, and is not nearly as extensive to-day as it was. At the present time the Ostrich is found distributed over the greater part of the African Continent, but has, to a great extent, become extinct in Asia, though there is little doubt, as is shown by fossil remains, that at one time the Ostrich extended as far as the North-East of India.

Variety.—Although the Ostriches through the Continent of Africa may be classed as one species, they may be split up into four varieties. First, the North African (*Struthis camelus*). These are found all along the northern part of the continent, ranging eastwards to Egypt and Abyssinia, and south to the Southern Soudan, and it was a subdivision of this variety which formed the shipment introduced into South Africa in 1912. The characteristics of the North African Ostrich are: the bird is very long in the legs, the colour of the skin in the hen is a creamy or very light salmon colour, and the cock, when in full sexual vigour, is a bright scarlet. The top of the head in both sexes has a bare, horny patch quite devoid of hair or feathers. The shell of the egg is quite smooth—*i.e.*, quite free from pittings, as is the case with the egg of the South African variety. Second, the East African Ostrich (*Struthis massaicus*), found principally in Massai Land. The characteristics of this variety are not well defined, and in many ways it appears intermediate between the North African and the South African. It has the same bare patch on the head as the Northern bird. Third, the Somali Ostrich (*Struthis molybdophanis*), so called from the colour of its plumage. It is found principally in Somaliland, and is the smallest of the four varieties. The skin colouration is a dull bluish-grey or leaden colour. Fourth, the South African Ostrich (*Struthis australis*). The skin colouration of this bird is a dark bluish-grey. The bare patch on the head is absent, and the shell of the egg is pitted and thicker than that of the Northern bird. Some very interesting cross-breeding experiments have recently been carried out between the imported North African and South African Ostrich. The external appearance of the cross-bred chicks is more like the North African parent stock. In the case where the North African hen was mated with the South African cock, a peculiar feature was noted,

namely, that the eggshells of this cross were only pitted in certain patches, other patches being quite smooth.

Domestication.—Until recent years it was thought that the Ostrich was first domesticated in South Africa, the approximate date of this domestication being 1863. In recent years it has, however, been discovered that the Ostrich was and is kept in a state of domestication in the Soudan, and has been kept in this state, as far as can be ascertained, for centuries. The method of keeping birds in domestication in the Soudan is, however, entirely different from that practised in South Africa.

Both methods started in the same way, *viz.*, by catching chicks of the wild birds and raising these by hand; in the Soudan this practice has always been continued. Chicks are caught, raised by hand, and kept until the birds become too old to produce feathers of paying quality, when in many parts they are killed and eaten in exactly the same way as cattle or any other class of stock. The system of farming these birds is to enclose each bird in a small circular mud wall or enclosure, about 8 feet in diameter; the birds are never given an opportunity to breed, and this practice, being continued for centuries, has led to the belief that the Ostrich will not breed in captivity. This state of affairs is now being remedied, both in Egypt, British Nigeria, and the French territory adjoining British Nigeria. The system practised of removing the feathers from these domesticated birds was the crudest possible, and, in fact, was and is governed by the fact that if one of the native farmers requires money, he pulls as many feathers from the bird as it possible to remove and sells these. The stage of the growth of the feather is not considered to any extent, and for this reason the feather sockets are damaged, and in the course of two or three years the bird produces worthless feathers. This practice is being remedied, and in course of time will undoubtedly be replaced by the methods practised in South Africa, where the Ostrich is the best-cared-for and most pampered animal in existence. In South Africa the practice differed from the North in this way: that when the wild chicks reached the age of maturity these were allowed to breed, and from these our domesticated stocks have been produced, and, due to the careful handling and selected breeding, the feathers have been vastly improved. The methods of handling and the taking of the feathers will be dealt with under the headings of clipping and quilling and management.

Chick-Rearing and Artificial Incubation.—As before stated, the Ostrich was domesticated in 1863. There are several claims for the post of honour of the first domesticator of Ostriches, and it is difficult to decide as to which farmer really first domesticated the Ostrich. Prior to 1863 all the feathers exported from South Africa were taken from wild birds which were killed by hunters.

Incubation and Chick-rearing may be classed under two

headings, "Natural" and "Artificial." In the natural order of things, when the Ostriches reach their full maturity (generally from two to three years, they make their first nest. If unlimited hens are available, a cock will usually mate with at least two or three hens for a single nest. Under improved farming conditions, however, it has been found that the best results are obtained by mating a cock with one or two hens, and enclosing these in a small paddock about two acres in extent. The birds usually select a sandy spot for their nest, which consists of a hollow or saucer-like depression in the ground made by the cock bird, and it is not an unusual sight, when Ostriches are nesting, to see the cock bird resting on his breastbone scratching up the ground for this purpose, in much the same manner in which the ordinary barndoor fowl does when taking a sandbath. In the completed nest the hen lays anything from 8 to 20 eggs, at the rate of one every second day. Incubation is then started; the hen hatches by day and the cock by night. This is continued till the forty-second day, when the chicks make their appearance.

Artificial incubation is carried out by means of incubators. The heat is generally conveyed to the eggs either by means of a hot-water tank or by hot air. In both cases the heat is generated by an oil lamp, which is placed at the side of and connected with the incubator by means of pipes. The temperature in the egg drawer is kept at from 99° to 100° F. (the normal temperature of the Ostrich is 103° F.). The eggs have to be turned twice a day to prevent the germ adhering to the side of the shell. As the evaporation from the eggs is very great, moisture must, in artificial incubation, be supplied from time to time. In natural incubation this moisture is absorbed from the ground and the body of the bird, but in artificial incubation it must either be supplied by damping the eggs from time to time, or by means of a tray of water inserted under the drawer which contains the eggs. It has been found that if the temperature in the incubator is kept fairly high the chicks hatch sooner, and *vice versa;* but, as stated above, the best results are obtained by keeping an even temperature of 99° to 100° F. In this case the chicks will generally emerge from the shells on the forty-second day. After the chicks are hatched they should be kept without food for about three days (until the swelling behind the head disappears); they may then be allowed to pick up broken eggshells, grit, finely-ground bone, crushed mealies, and a moderate amount of green food, such as lucerne, rape, etc.

In natural rearing they are allowed to run with the parent birds, who teach them to eat a great variety of foods, and they are also given a great deal of exercise. This has, up to the present, been found to be quite the healthiest method of rearing the chick, but may possibly be superseded by an improved method of hand-rearing in the near future, should the experiments in this respect prove wholly successful.

In artificial rearing the chicks are placed in charge of a herd, who should be instructed to take the chicks for a fairly long walk on the veld every day. They are thus enabled to pick up the grit required by their digestive organs, and also procure a fairly wide range of foods. The exercise is very essential to their well-being. Under this system of rearing the chicks become very tame, which is a great advantage when they become older.

Internal Parasites.—With the exception of its susceptibility to internal parasites—tape-worm and wire-worm—the Ostrich is an extremely healthy bird. The losses caused by these two pests is, however, at times very severe. Tape-worm usually makes its appearance in the chicks when they reach the age of two weeks, and may be detected by the small white specks which appear in the freshly dropped dung. These are sections of the tape-worm, and are filled with spores. The medium of infection has not yet been definitely ascertained. The tape-worm itself may be from 6 to 36 inches in length. The usual means employed for checking this parasite is dosing with either petrol or turpentine, and the dose should be administered every fortnight or three weeks, and is often continued until the chicks reach the age of 18 months. When three years old the birds are no longer troubled by this parasite. Wire-worm usually makes its appearance when the chicks are about six to nine months old, and is a much more serious parasite than the tape-worm. Beyond the rapid falling-off in condition of the bird, there are not many symptoms by which it can be detected. On making a post-mortem examination, however, the lining of the proventriculis or glandular portion of the stomach will be found to have a thick layer of jelly-like substance adhering to it. On scraping this away thousands of wire-worm will be seen adhering to the tissue of the stomach. In appearance they are red in colour, about the thickness of a human hair. The usual means employed in combating this parasite is dosing either with sal-ammoniac and lime, carbolic acid, or carbon bisulphide, but as all these remedies are rather severe in their action, they should only be administered when really necessary.

Feeding and Management.—The comparative ease with which the Ostrich may be fed is one of the points that has rendered its domestication an easy matter. It feeds readily on all the ordinary fodders which the farmer, and especially the Karroo farmer, usually grows for his other stock, such as sheep and cattle. Thus with a great number of South African farmers Ostriches are run more or less as a side-line in addition to their other farming operations. The best albuminoid ratio for breeding birds has been found to be 1:4.5, and for feather growth about 1 : 6. The foods most commonly used are mealies, Kaffir corn, oats, barley, prickly pear leaves, aloe leaves (*Agave Americana*), monketaan (desert melon), mangel,

green lucerne, rape, kale, green barley, lucerne hay, bran, etc. A certain amount of bone should always be supplied to the birds, and if the pasturage be devoid of grit, this should be supplied; for this purpose white quartz has been found to give excellent results. The Ostriches swallow the grit readily, and the grit assists the digestion by grinding up the food, which the Ostrich swallows whole. Grit is so essential that in some parts of the country it is carted by waggon or by rail for many miles, as it was found that without it the birds would not thrive—in fact, could not exist.

Clipping and Quilling.—The method of taking the feathers from the bird as practised under South African farming methods is as follows:—

When the chick reaches the age of five to six months, the first feathers are cut from the wings. These are known as "spadonas," from their spear shape. The quills of the feathers are then allowed to remain in the wings until all the blood has receded from them, and they become quite dry and hard. This takes from two to three months, and the dry quills can then be drawn from the wings without causing the least pain or loss of blood. If not drawn, they are pushed out by the next crop of feathers, but the moulting is uneven, and hence the method of removing the quill stumps artificially is recommended. In six months' time the next crop of feathers will be ready to clip, and three months later the quills may again be drawn. This alternate clipping and quilling is then continued for the rest of the bird's life. This practice can be carried on very successfully in parts enjoying a fairly even temperature, but in districts where the winters are very cold it has been found advisable to take only one clipping each year, for the young feathers do not start evenly from the wing when the bird is quilled in very cold weather.

Quilling should only be carried out when the bird is in good condition, and this condition should be maintained throughout the period that the feathers are growing. Condition has been found to have a most marked influence on the feather growth, and, generally speaking, the better the condition of the bird, the better and sounder are the feathers produced; thus it will be seen that it behoves the Ostrich farmer in his own interests to keep his birds in the best of condition, and give them the best treatment possible, and it may therefore be stated, without fear of contradiction, that at the present day the Ostrich is the most pampered creature in existence.

Marketing of Feathers.—As a general rule the farmer sends his clip of feathers as the feathers come from the bird, without any previous sorting or grading, direct to his market agent, who sorts them into grades to suit the buyers, and places them on the market, where they are sold by public auction. The buyers ship them overseas, chiefly to London, Paris, and New York, where they are disposed of to the manufacturers. Those

feathers going to London are again sorted on reaching there—this time according to the manufacturers' requirements, which is a very much finer process. They are then catalogued and placed on view for a fortnight, to enable prospective buyers to estimate their approximate value, and are then again disposed of by public auction.

The greatest bulk of feathers goes to Great Britain, France, and America, and a smaller portion to Austria, Germany, and Russia, etc. Of recent years several attempts have been made to introduce feathers into China and Japan, but the difficulty up to the present has been that the people of the East very seldom wear hats, and when they do, they are purely as a protection against the weather, and not as an article of decoration, as in the West. It is to be hoped, however, that with the spread of European fashions, and the carrying out of schemes recently evolved for the purpose of popularising the Ostrich feather, the desire for this beautiful article of decoration will be increased, and that the markets for Ostrich feathers will be very much extended in the future.

Uses of the Ostrich Feather.—When one considers the enormous variety of uses to which Ostrich feathers are put, it is hard to conceive of such an industry becoming an absolute failure, and although the market will always be subject to fluctuations due to changes of fashion, it is difficult to imagine the demand for Ostrich feathers dying out altogether.

Of course, the first and principal use of the Ostrich feather is as an article of decoration on ladies' hats; for this purpose the very best feathers are used, particularly when the feather is used in its undressed or natural state. These feathers fetch the highest prices, and consequently, when ladies are wearing the greatest number of feathers on their hats the Ostrich farmer is procuring the greatest profits. Next comes the manufacture of Ostrich feather fans. For this purpose good feathers of several different kinds are used.

Next is the manufacture of Ostrich feather boas. In the making of these the flue or soft portion of the feather only is used, and for this reason damaged and inferior feathers are largely used for the purpose.

The flue of the most inferior feathers is used for padding clothes and quilts for use in cold countries. As will easily be understood from the foregoing, where the uses of the Ostrich feathers are so extremely varied, it is quite possible that when one particular class of feather is down in price, another line may be booming, and, as previously pointed out, it is very unlikely that the demand for Ostrich feathers will ever completely die out.

In conclusion, I would like to point out the enormous strides made by the Ostrich industry since Ostriches were first domesticated in South Africa, and the enormous benefit derived from the industry in South Africa. In 1865 there were 80 domesti-

cated Ostriches in South Africa; the weight of feathers exported was 17,000 lbs., most of which were wild birds' feathers, valued at £65,000. In 1875, ten years later, there were 32,000 domesticated Ostriches; the weight of feathers from wild and domesticated birds exported was 100,000, valued at £300,000. In 1891 there were 154,000 domesticated Ostriches; weight of feathers exported, 212,000 lbs.—this probably included a small weight of wild birds' feathers; value, £563,000. In 1904 there were 307,000 domesticated Ostriches; weight of feathers exported was 470,000 lbs., valued at £1,058,000. In 1908 there were 700,000 domesticated Ostriches; weight of feathers exported 800,000 lbs., valued at £2,098,000. In 1913 there were 1,000,000 lbs. of feathers exported, valued at £2,750,000.

From the above figures, it will be seen how rapidly the Ostrich feather industry developed in South Africa, and it must be remembered that when Ostriches were first farmed the methods adopted were naturally crude, due to want of knowledge. The feathers were pulled from the wings every six months, when they reached the highest state of perfection. This practice was soon found to be very detrimental to the feather-producing capacity of the bird, and it was found that by clipping the feathers, and after clipping leaving the quills in for a period of three months, and removing these just about the time they would have been shed by the bird, far better results were obtained, and that the bird would go on producing good feathers for practically an indefinite period. This method is absolutely humane, and the bird certainly does not receive any injury whatsoever, not even the small injury that a sheep will receive in shearing when he is occasionally nipped by the shearer. Then, again, feeding was found to have a very marked effect on the feather growth, and this led to the pampering of the bird to such an extent that at the present day the Ostrich is practically fed on everything that it desires. It was found that this method of humouring the appetite of the bird produced the best results. The fact that the highly-fed Ostrich gave the greatest financial return was the cause of the erection of the great majority of the biggest irrigation works undertaken in South Africa, and the return was so enormous that many irrigation works which could not possibly have been undertaken otherwise were carried out as paying propositions, and are to-day a source of great wealth to the country. Ostriches also gave rise to a great deal of first-grade fencing, as it was found that only fences of the best type were suitable, not only in keeping the birds in the paddocks in which they are run, but also bad fences were found to be responsible for a number of casualties, as birds would be cut and disabled in such fences. It will therefore be seen that whatever happens to the Ostrich industry in the future—and there is no reason to believe that the industry will ever go to the wall—the farmer is under an inestimable debt of gratitude to the Ostrich as being the

means by which the best areas of arid land have been converted under irrigation into highly productive fodder-producing areas, which, even if the industry were to fail, would be of incalculable value as fodder-producing areas for any class of farming.

Ostrich feathers have, for centuries, been used for purposes of adornment, first by men and afterwards by women, and as the feather is an article of great beauty, it will undoubtedly always be considered as an article of adornment by the ladies throughout the world, though, like all fashions, it is likely to have its ups and downs; but an industry which in 48 years has risen from an export value of £65,000 to £2,750,000 will never be allowed, by those concerned, to go to the wall, and it behoves us in South Africa, who have profited to the extent of all our greatest irrigation schemes, and most of our good fencing, to support and forward the interests of this industry in such a manner that it will always remain on a firm and well-established basis.

LATICES FROM SOUTH AFRICAN PLANTS.—The *Bulletin of the Imperial Institute* records* a number of investigations into the nature of samples of latex received from different parts of South Africa and derived from various plants. In practically every case these latices contailed large quantities of resin and little of true caoutchouc, and the "rubber" which they yielded was sticky and did not show the physical characteristics of true rubber. Some crude latex of *Euphorbia Tirucalli* from Natal contained, in the condition in which it was received in the Imperial Institute, 51.2 per cent. of resin and 9.7 per cent. of caoutchouc. Various tests were made with the resin and proved it to be unsuitable for making varnishes. On dry distillation the resin behaved like colophony, but it has not yet been determined whether the products are similar to those obtained from colophony, and whether they could be used for similar purposes. Two samples were received from Rhodesia: one of these was the coagulated latex of the "Tshizimboti" tree, but the specimens of the "tree" which accompanied the sample of latex were found to represent two different species of *Euphorbia*. This latex also yielded a resin closely resembling the other *Euphorbia* resins previously examined. The other Rhodesian sample was a rubber-like substance, apparently derived from *Ficus utilis* Sim. It contained more caoutchouc and less resin than the material derived from *Euphorbia Tirucalli*, and was therefore superior to the latter. The coagulated latex of *Conopharyngia elegans* from the Transvaal was also examined. Here again the sample was found to be very resinous, and it showed but little elasticity or tenacity. It was valued at 3d. per lb in Europe, a price at which its collection in the Transvaal is hardly likely to be remunerative.

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THE RELATION OF BODY AND MIND.

By Rt. Rev. Arthur Chandler, M.A., D.D.

This problem might be described as that with which all philosophy from the beginning has been dealing in some sense or other; but it has lately acquired a fresh and urgent interest from the investigations of physiological psychology. We start with a rough common-sense dualism of mind and body as distinct things, which, though very different in character and operation, necessarily influence each other, and which, being bound to live together (like Boer and Briton), have to establish a *modus vivendi* as best they can. But if we are actuated by that curiosity which we are told is the starting-point of philosophy, we are constrained to go on and ask what is the nature of this reciprocal influence, how a spiritual or immaterial principle and a spatial network of nerves can act upon each other, and how far either of those two factors is deflected from its natural mode of operation by such inter-action.

The difficulty of understanding how an immaterial and a material something can find a connecting ground on which they can get at each other and co-operate or even conflict with each other, leads obviously and naturally to a re-statement which declares that the two processes, the mental and the physical, simply operate side by side without really touching each other or influencing each other at all; and here we have the theory of "psycho-physical parallelism." When we think of anything or desire anything, the mental thought or desire is accompanied by a certain change in the nervous tissue; the two processes are parallel with each other without any causal influence being exercised by the one upon the other. Such a theory may be formulated, but it simply shelves, and refuses to face, the problem; it is difficult to hold it at all without introducing a *deus ex machina* in the shape of some pre-established harmony which ordains arbitrarily that there shall be such a state of things; and, further, it fails to satisfy the claims either of common-sense or physical science. Common-sense asserts that this mental process does not merely run parallel with the physical process, but dominates and controls it, exercises a causal influence upon it; and, on the other hand, physiology repudiates such intrusions on the part of a mental factor, holds that the nervous system is an independent, self-working entity, and that such mental phenomena as thoughts and desires are casual effects thrown off by the nervous system in the course of its own strictly mechanical operation.

This latter contention gives us the theory of "epi-phenomenonalism," according to which the brain is a machine whose operations are causally determined by mechanical laws and by nothing else, each mental disturbance being a necessary result

of its material antecedents, and in no sense affected by such mental states as desire or volition. But, as any machine does its work, sparks may fly out, or an engine may whistle, and there are regular rhythmical pulsations of sound, things which result from the working of the machine, but which are quite unimportant and irrelevant by-products of its action, and that is the position which this theory assigns to all mental processes; they are merely effects of bodily processes, and unimportant casual effects into the bargain. The only criticism that we need pass here is that, however much one may wish to disparage the work of the mind, we cannot disguise the fact that it is at any rate different in kind from that of the body—lower and less important if you like, but at any rate belonging to a different level or order of things. The fact makes the illustrations I have given quite futile. The whistling and clanking and throbbing of an engine are on the same level as the more important movements of its pistons and wheels; but desire, thought, and volition are not on the same level as the afferent or motor discharges of the nerves. There is not sufficient common quality to enable us intelligently to call the one effects of the other. We can say that the two processes go on together, but not that the mental process is the product, however casual, of the bodily process. In other words, we are forced back to parallelism, which at any rate recognises that brain processes cannot be said to cause mental states.

And we seem to be brought to the same pass if we take the opposite view to epi-phenomenonalism, and regard consciousness or conscious states as the sole reality, and the bodily states as a delusive appearance, as a sort of shadow thrown by the mind. According to "psychical monism," everything is soul or soul-stuff; but one soul can only manifest itself to another in material bodily form; body is the unreal appearance of soul. But it is difficult to understand why even this unreal appearance should exist; if soul is everything, why in the world should it appear as body? Why should not soul act directly on soul, as there are indications of its doing in cases of telepathy? If the body is real, it is obvious that soul can only reveal itself to soul through bodily action and appearance. But if body does not exist, why should soul insist on masquerading in bodily form? This seems to be as awkward a question for psychical monists as it is for Mrs. Eddy and the Christian Scientists. It seems just as impossible to regard body as a shadow cast by soul, as it is to regard soul as a phosphorescence cast by body. Neither soul nor body can be reduced to the same order as the other, explained in terms of the other, and made the ghost or the bond-slave of the other.

Unless, then, we return to parallelism, and say that the two orders exist side by side without touching or influencing each other, we must proceed to some theory of their mutual interaction. And, by talking of interaction, we allow that both mind

and body are equally real and reciprocally act upon and influence each other.

To me it seems fairly clear that we must hold some theory of interaction—that the mind does in some way control and set in motion processes of the nerve-system, and that the body influences the mind in materialising its thoughts or making them symbolical in character. But as the theory of interaction is usually stated, it seems open to very serious objections. The brain is presented to us first as an independent system, actuated exclusively by mechanical laws of natural causation, and then, because such a system so actuated cannot explain psychical facts, another independent principle, called the soul or mind, is brought in and is represented as influencing and controlling a system which, we were just before assured, was a system operating exclusively by mechanical laws. I think Clifford speaks somewhere of a train, in which the luggage van is connected with the rest of the coaches by the feelings of friendship between the guard and the engine-driver.

How can a system governed by mechanical and chemical laws and working by natural causation find room for the mind with its implications of freedom and purpose and intelligent choice? Does not the theory of interaction simply try to mix up things which are mutually incompatible? According to it body becomes a mechanical system which fails to act by mechanical law (so far as an influence of mind is admitted), and mind becomes a spiritual system which does not act spiritually, but mixes itself up in mechanical processes. Both systems fail to be true to their own special and characteristic principles.

It is difficult to understand whether mind interferes occasionally with a process which is normally mechanical, or whether it is essentially mixed up in these processes; and equally difficult to understand how either one or the other is possible. In order to illustrate what seems to me the way out of the difficulty, let us consider the case of an ordinary machine. Here purposive contrivance and dead mechanical action are both present. Each part of the machine has its purpose in connection with the whole, and the whole again has its purpose in connection with the needs or comforts of human life. But this purposive element is imported from within. It was located in the mind of the engineer who made the machine; the machine itself knows nothing of such purpose; no cog or piston or wheel recognises any community of interest with the others, but all work in blind obedience to mechanical law and in absolute indifference to any useful result that may ensue.

But let us imagine a machine which is itself active and purposive, instead of having its purpose imparted to it from without; and we shall have a picture of the interaction that we want. The influence of the life and the mechanism will be reciprocal. On the one hand the purposive life will only be able to manifest itself under material conditions; will have to grind itself out

piecemeal and in time; but, on the other hand, the mechanism will be controlled throughout by the purposive life which pervades it in every part. And, moreover, the two will develop together. As the purposive life grows, the mechanism will alter and modify itself, and, *vice versa,* the increased complexity of the mechanism will enable the purposive life to become richer and fuller and more far-reaching in aims and ideals. And this seems to be what has actually happened in the course of evolution. All life is purposive, and contains the germ of the most advanced developments of mind. It seems futile to say that at no point in evolution can we detect the emergence of mind, and that, therefore, there is no such thing. Mind is present in all life; the purposive character of life is its mental character; at the earliest stage that purpose is faint and primitive, corresponing to the undeveloped structure of the organism. The amœba manifests purposive life in protruding or contracting itself in accordance with the bodies with which it comes into contact. And as the organism becomes more complex in structure, the purposive life becomes subtler and fuller: It is a vital unity interfused with the material structure and governing and regulating the action of that structure. Thus a purposive character is impressed at every stage upon the structure; at every stage it is soaked in mentality; it is just the instrument used by the life which indwells it with the object of avoiding collisions or obtaining nourishment, and so on. At a later period, coincident with the further development of the structure of the brain, the organic life itself becomes more complex, and manifests itself in those cognitive, conative, and affective aspects which we know as reason and will, and desire, but which are simply aspects of the organic life in its advanced stage, and to which we tend to ascribe far too much in the way of separateness from each other. And by this time the nervous system has become a highly elaborate, minutely differentiated structure, sufficiently complex and delicate to express these various departments of the indwelling life.

In other words, what we come to see is this: instead of the crudely dualistic conception of a purely immaterial mind interacting somehow or other with a purely material bodily mechanism, we have the concrete conception of a single living organism in which whole and parts are mutually dependent on each other; the vital unity is the whole, and the nerves are the parts. The life is the whole which directs and gives purpose to the parts; while the parts in their turn build up and support the whole. Roughly, then, the relation of mind and body is the relation of the whole to the parts, of the life and the organism. The value of such a conception is that on the one hand it maintains a real distinction between mind and body, and provides for the growth of both through their interactions with each other, avoiding the static immobility which theories of monism seem to imply; and on the other hand, it makes

intelligible the fact of interaction, which remains a problem or an impossibility on strongly dualistic theories.

On the one hand, mind and body are for ever distinct, they cannot be identified, nor can either be sacrificed to the other—made a shadow or a spark casually effected by the other; their distinctness, their interactions, their occasional warfare, is the source of all progress in science and morals.

On the other hand, though distinct, they are not aliens. It is not true that the one is absolutely spiritual and the other entirely material. If that were so, there could never be any interactions, but only juxtaposition of the one with the other, and perhaps the annihilation of one by the other.

But as a matter of fact, through their constant interfusion with each other, the mind has become materialised and the nervous system mentalised. The mind is just the purposive whole controlling the parts; it has always been limited to the use of those parts; it works piecemeal and in jerks, not in timeless contemplation, just because successive nerve stimuli and nerve reaction are the instruments it uses; its ideas, again, on the most spiritual themes are symbolical, are pictures or parables from the material sphere, because it only has matter to work on. The mind is free and purposive; but its freedom is exercised upon, and its purposes are wrought out in a material medium. The mind is just so far distinct from the body as the whole is from the parts, as life is from the organism. The life is interfused with every part of the organism; it depends on the organism on the one hand, and directs it on the other; and one aspect of this organic life is what we call the mind. Thus we have, in Bosanquet's words, a "moulding of the soul through its surroundings—the modification thus brought to these surroundings, and the results achieved through them."

And on the other side, we must remember that the cerebral system is itself moulded and constituted by purposive action in the past. It reacts to-day in a certain way, its motor discharges are in a certain direction, because of the purposes to which it has been made instrumental yesterday and the day before. It is not a blind immaterial mechanism, but is charged with instincts, habits and automatic arrangements, which are due to mind and make it akin to mind. It is a system of mentalised parts able to interact with a necessarily materialised living mind. It is a system of parts which imply and demand the whole, just as the whole is limited to the use of the parts. And I might just suggest, in conclusion, that this conception of whole and parts is fruitful beyond the sphere of the individual life. Just as in that individual life the mind, as the whole, uses the body as the parts, so in social life the individual freely surrenders himself as a part to be used in the service of a larger whole. He and other individuals together make up that whole, they are saturated with the spirit of the whole, they wake up to their true nature as members of the whole; and on the other hand, this social

whole is limited in its action to the use of the individual members; it waits upon them, cannot go beyond what they are prepared and able to do, is built up of their individual wills and convictions and desires.

And it is the same in religion, where individuals again surrender themselves as instruments to be used by a divine life which realises its purposes through them; so that they become "members in particular" of Christ, and Christ is fulfilled in them.

Thus the relation of the whole and the parts, of the life and the organism, seems to run through and throw light on the relation of mind and body in the individual, and in the relation of the individual to the larger spheres.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, August 14th: W. Ingham, M.I.C.E., M.I.M.E., President, in the chair.—"*Description of collapse and recovery of central incline shaft, Bantjes Consolidated Mines, Ltd.*": P. **Cazalet** and W. W. **Lawrie**. The subsidence was due to a decomposed dyke becoming saturated with water from heavy rains and being converted into a plastic mud. The whole weight of the saturated mass was thrown on the roof of the shaft, which fractured under the stress. The weight was thus transferred on to the steel shaft framing, which collapsed with practically no warning. The steel setts collapsed totally for a distance of 95 feet, and partially for 35 feet more. The author proceeded to outline the method of recovery adopted. Travelling timber setts were first introduced; permanent caps of pitch pine, fitted on the top with boxing, were then placed in position, and finally concrete walls, extending 40 feet above and 45 feet below the fall, or 180 feet in all, were built up, and just two months after the accident hoisting recommenced—"*Notes on Monel metal*": E. **Goffe.** Monel metal, the natural alloy of nickel and copper, reduced from its ores without change of combination, resists corrosion to an extraordinary degree. The author detailed certain tests made in the testing laboratory of the Government Mines Department, which clearly demonstrated the alloy's strength, ductility and toughness. Chemical tests had shown that the action of ordinary mine water on monel metal is inappreciable, that immersion for two days in 3½ per cent. sulphuric acid affects the metal only slightly, that a .12 per cent. solution of potassium cyanide has no greater effect during five days immersion, and that free hydrocyanic acid (.05 per cent. solution) acts on iron with five times greater strength than on monel metal.

Saturday, October 9th: W. Ingham, M.I.C.E., M.I.M.E., President, in in the chair.—"*Machinery Accidents on the Gold Mines of the Witwatersrand*": C. B. **Pattrick.** The author furnished tables showing the proportions of casualties due to machinery and the number of these classed as preventible, the effects of personal and of impersonal causes in general, and with special reference to preventible accidents. Compensation tables were added showing *inter alia,* averages per casualty for white and coloured persons, and for fatal and non-fatal cases.

Saturday, October 9th: W. Ingham, M.I.C.E, M.I.M.E., President, in the chair.—"*Preparation of large type Babcock and Wilcox boilers for test*": H. **Martin.** The author began by describing the construction of the boilers, and then described the preparations made for a large number of test observations and operations, concluding with an outline report on the Victoria Falls and Transvaal Power Company's last official "taking over" test at Brakpan Power Station.

Saturday, November 13th: W. Ingham, M.I.C.E., M.I.M.E., President, in the chair.—"*Jo'annesburg Town Hall*": W. **Hawke**. A general description of the building was given, including particularly the Selborne Hall, on the first floor, an apartment of 91ft. × 47ft. and 31ft. high. Flatpan stone from the Orange Free State was employed for the façades, and in all approximately 120,000 cub. ft. of stone, and about five million bricks were used. General constructional details were given, as well as an account of the more important steel-work items in the building.

Saturday, December 11th: W. Ingham, M.I.C.E., M.I.M.E., President, in the chair.—"*The relative efficiencies of blasting gelatine and gelignite as used in hand drill stopes in the gold mines of the Rand*": **W. S. Simpson.** The paper comprised an account of experimental work carried out on behalf of the Vogelstruis Estates and Gold Mines, Ltd. In two stopes of entirely different character, blasting gelatine proved 25 per cent. more efficient than gelignite as an ore breaker. The relative efficiencies of the explosives agree closely with the comparative ballistic strengths determined by the ballistic pendulum method. Forty per cent. ligdyn as a primer largely reduces the efficiency of gelatine, and probably also of gelignite. Blasting gelatine gives greater efficiency with No. 8 than with No. 6 detonators.

Royal Society of South Africa. — Wednesday, October 20: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President in the chair. —"*A South African species of Pelodrilus*": Prof. E. J. **Goddard** and C. S. **Grobbelaar.** The specimens described constitute the first recorded occurrence of the genus *Pelodrilus* in South Africa, and were obtained from Sneeuwkop, near Wellington, at an altitude of 4,500 feet. The distribution of the genus has hitherto been restricted to the Antarctic region.—"*Preliminary note on ancient human skull remains from the Transvaal*": S. H. **Haughton.** Skull remains found at Boskop, Transvaal, and the manner of their occurrence were described. The remains consist of the greater part of the skull-cap, a temporal bone, and a portion of the lower jaw. The skull-cap is the longest known, with the exception of that of La Chapelle-aux-Saints. Its greatest affinities are with the skulls of the Cro-Magnon type. The forehead and anterior half of the skull agree with the Cro-Magnon and Bantu types, and not at all with the Neanderthal. The lower jaw is comparatively small and akin in character to that of the Bantu or Bushman type. —"*The Elastic Arch continuous over several spans, capable only of small rotary motions at the supports*": A. N. **Henderson.**—"*The Heating Coefficients of Rheostats and the calculation of Resistances for currents of short and moderate duration*": Prof. H. **Bohle.**—"*Further Magnetic Observations in South Africa during the years* 1914-1915": Prof. J. C. **Beattie.** The declination, dip and horizontal intensity were given for 27 stations, including two repeat stations in the Free State, Transvaal, and Cape Provinces.—"*True Isogonics and Isoclinals for South Africa for the Epoch* 1st *July*, 1913": Prof. J. C. **Beattie.** The results at about 700 stations have been reduced to the epoch from observations at about 40 repeat stations fairly distributed over the greater part of the region. The westerly declination has decreased in the ten years 1903-1913 by about 1½ degrees in the west, and 2 degrees in the east. In the same period the southerly dip has increased by approximately 1 degree in the east and 1½ degrees in the west.—"*Descriptions of some new Aloes from the Transvaal*": I. B **Pole-Evans.** The author described the following six new species of Aloes:—*A. verecunda*, *A. Simii*, *A. Barbertoniae*, *A. petricola*, *A. sessilifolia*, and *A. Thorncroftii*.—"*A new Harmonic Analyser*": Prof. J. T. **Morrison.** In many physical researches, especially in meteorology, it is necessary to enquire whether a fluctuating quantity, such as atmospheric pressure, daily or monthly rainfall and the like, shows signs of regular periodic variations, and the necessary operations are performed mechanically by the harmonic analyser described.

South African Society of Civil Engineers.—Wednesday, September 8th: R. W. Menmuir, A.M.I.C.E., Vice-President, in the chair.—"*Pietermaritzburg-Riet Spruit Deviation, Natal Main Line*": D. **Wilson.** An

account was given of the various surveys undertaken in order to improve the Natal Main Line between Pietermaritzburg and Riet Spruit, and of the main economic features of the deviation eventually decided on, and now under construction.—"*Notes on the reconstruction of railway, Lüderitzbucht to Windhuk*: W. G. **Cocks.** The whole distance from Lüderitzbucht to Windhuk, in German South-West Africa, is approximately 540 miles. A general description of the line was given, followed by an outline of the reconstruction work. The plate-laying was carried out by a day and a night gang, each comprising some 150 natives, under control of a railway engineer officer, and accompanied by the necessary complement of sapper plate-layers. Ahead of these gangs was a permanent fatigue party of 100 Kaffrarian Rifles, clearing ballast, getting sole plates ready for the reception of rails, etc. In advance of these was a rail-cutting party of 160 natives. Examples were given of the nature of the work done by these: thus, between 2nd April and 17th May, a section of the line 76 miles in length, whereof every rail had been destroyed, was reconstructed and opened for traffic. The total number of rail cuts was 49,516. With regard to bridges, 42, principally plate girder and truss types, which had been destroyed, were repaired, bird-caged, and trestled. At the watering staions, 21 in number, the pump heads had been destroyed in nearly every case, the boreholes plugged with debris, and all the wells had been poisoned. A section of the Engineer Corps was detailed to obtain water and repair the boreholes ahead of the construction train, and so there was generally sufficient water available to work the train forward.

South African Institute of Electrical Engineers.—Thursday, September 16th: B. Price, M.I.E.E., President, in the chair.—"*Notes on three-phase transformers*": A. N. **Aikman.** The points discussed with more or less detail included temperature rise, overload capacity, sludging of oils, parallel running of transformers, etc.

Thursday, October 21st: B. Price, M.I.E.E., President, in the chair.—"*Some notes on the comparative costs of compressed air and electricity for use in mine stope haulages*": A. E. **Middleton.** The following comparative conditions were shortly discussed: (1) relative consumption of air and electricity, corrected for transmission and transformation losses, (2) relative maintenance costs, (3) relative first costs. The author arrived at the conclusion that the air winch costs five or six times more for power to run than the electric. In regard to repairs and maintenance, the total monthly cost for an air winch was estimated at £3 15s. 8d., and for an electric winch £2 18s. 6d. On the other hand, the heavy cost of cables for electrically-driven winches is the chief adverse factor against their adoption.

Thursday, November 18th: Prof. W. Buchanan, M.I.E.E., Vice-President, in the chair.—"*The distribution plant of the Johannesburg Municipal Electric supply system*": Prof. J. H. **Dobson.** A comprehensive description of the various distribution systems was given under the following heads: (1) the "inner" or town area, (2) the "outer" or suburban area, (3) the power supply to the tramways, (4) public street lighting. The author concluded by comparing the system as it was in 1909 with its dimensions in 1914. During this period the connections to the mains increased from 5,720 to 16,091, and the total units consumed from 11 millions to 25 millions. The number of consumers connected to the Johannesburg electric distribution system is approximately equal to those on the whole of the other municipal undertakings in South Africa.

Tuesday, December 21st: B. Price, M.I.E.E., President, in the chair.—"*A power factor diagram*": C. J. **Constancon.** The author exhibited and described a diagram from which the power factor of a circuit can be found immediately, without any calculation from the two wattmeter readings of a three-phase system. The readings of the two wattmeters are looked up on the orthogonal axes of the diagram, and then, by following up certain lines on the diagram, the resulting power factor is read off on a clearly-marked scale.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, October 16th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair.—"*Clean-up room practice at the Simmer Deep*": W. H. **Jane** and F. **Davey.** A detailed account of the processes for the recovery of gold and other precious metals and alloys, such as osmiridium, from the black sand swept from the plates, from the tube-mill liners, and from such articles as worn-out amalgam brooms. The clean-up room affords adequate space for all operations. It has a granolithic floor, which slopes to a channel leading to a sump. The sumps are cleaned out monthly, and yield an amalgam of 36 per cent. fine gold. All wood chips, blocks from tube-mill liners, waste, old launder belting, and other combustible stuff are periodically incinerated, and the ashes sold to the smelting works.

Saturday, November 20th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair.—"*Chief sources of accidents in the Witwatersrand Mines*": C. E. **Hutton.** During 1914 the separate accidents reported numbered 1,989, resulting in 608 deaths and 1,715 persons injured. Falls of rock were responsible for the largest number of accidents, namely, 451, resulting in 204 deaths and 371 persons injured; 234 of the accidents brought about by falls of rock were due to hanging walls, and these resulted in 139 deaths and 177 persons injured. The sum paid as compensation, during the year, in respect of deaths and injuries from accidents, was £116,115.

Geological Society of South Africa.—Monday, October 18th: Mr. D. Wilkinson in the chair.—"*On the Zinc and Lead or deposits near Zeerust, Western Transvaal, South Africa*": the late W. **Anderson.** Lead and zinc ores have long been known to occur in the Dolomite Series, south of Zeerust. Lead was the first metal to be mined, the zinc being passed over as valueless. The ores occur either in the form of localised areas in the dolomite, or as isolated aggregations of galena, often associated with similar aggregations of zinc blende.—"*Description of a carbonaceous mineral occurring in the Witkop Mine, near Zeerust, Transvaal*": Dr. C. **Anderson.** The mineral is confined to a zone extending to a depth of 100 feet, and occurs as spherical, flask-shaped, or irregular rounded pellets embedded in calcite. The carbon occurs in two forms, one black lustrous, highly polished and brittle, the other duller in appearance and soft enough to mark paper, like graphite. The former variety is chemically an anthraxolite of high carbon content (92.74 per cent.), while the latter is more akin to schungite.

Monday, January 31st: A. W. Rogers, M.A., Sc.D., F.G.S., President, in the chair.—"*The nature of the copper deposits of Little Namaqualand*" (Presidential address): Dr A. W. **Rogers.** The copper-bearing rocks of Namaqualand fall into two sharply-defined groups: (1) those which occur in veins, with a gangue of quartz, carbonates, felspar, and chlorite, and (2) those associated with igneous intrusions in gneiss. The first group is found in the northern portion of the country, and has not resulted in any notable output of copper; the second group is the basis of the copper industry, and covers some 2,000 square miles in the middle of the Namaqualand Division. In every mine which has paid its way there are patches of rich sulphide rock, the ore from which enables the poor ores to be worked under present conditions. The discovery of the conditions governing the occurrence of these rich bodies is the chief economic problem in the Namaqualand copper field.

South African Association of Analytical Chemists.—Thursday, January 20th: J. Moir, M.A., D.Sc., President, in the chair.—"*Locally-made Mahler bombs*": W. O. **Andrews.**—"*South African Grenades*": J. M. **Thorburn.** An exhibition was given of the different types of bombs that were being made, and a demonstration of their method of working.—"*Detection of water in milk*": Dr. J. **McCrae.** The paper described briefly methods which had been suggested for the detection of extraneous water in milk.

DIETETIC DEFICIENCY.

By Henry Hamilton Green, B.Sc., F.C.S.

The purpose of the present paper may at the outset be roughly stated to be a brief *résumé* of certain recent work upon feeding problems, and the significance of certain constituents of feeding-stuffs for the maintenance of life and health.

By way of introduction, it may be recalled that, until within comparatively recent years, the classification of the earlier physiologists, resulting in a differentiation of foods according to the proportion of proteins, carbohydrates, fats, and minerals which they contained, was regarded as fairly adequately representing all the constituents which had to be taken into account in considering the nutritive value of a diet.

A sharp distinction was of course drawn between the digestible and indigestible moiety of each constituent, and a great deal of classical work had already been done upon the digestibility of the various components occurring in different natural foods as fed to man and to live stock.

Long before the end of the last century, the compilation of tables showing the digestive coefficients and nutritive value of such food-stuffs was well advanced. A clear distinction was drawn between the metabolism of proteins, fats, carbohydrates, and minerals, and the broad functions of each in the animal economy was understood, although at the same time the distinction between different forms of these basal constituents was little more than recognised. The physiological significance, for example, of difference in *kind* of protein, was largely a matter of conjecture, and it was customary to measure the protein value of a food by its total nitrogen content, and to measure protein metabolism in the body by the excretion of total nitrogen in the urine. Definite relationships between the calorific value and intermetabolic equivalents of proteins, fats, and carbohydrates, were established, and feeding standards laid down for different classes of animals under varying conditions, due respect being paid to energy requirements and to the quota of protein necessary for the repair of waste tissue.

Concerning the more intimate processes of the living organism in relation to the destiny of ingested food, little was known. As Cathcart* puts it:—

> Carl Voit, even in 1902, after forty years of strenuous work, could say no more than that "the unknown causes of metabolism are found in the cells of the organism. The mass of these cells and their power to decompose materials determine the metabolism."

We are still in much the same position to-day, but yet the beginning of the present century may be regarded as bringing with it several strikingly new developments in the more detailed

* "Physiology of Protein Metabolism" (1912).

study of nutritional problems. The pioneer work of Emil Fischer upon the chemical constitution of the protein molecule opened up a new field for research. His demonstration of the fact that the protein molecule can be broadly regarded as a complex structure of amino-acid units led to the study, by numerous investigators, of the constituent units of the different proteins of plant and animal origin, which could be isolated in a sufficient state of purity for detailed examination. Linked to this came the study of the physiological significance of these units.

About the same time came a growing emphasis upon the "lipoid" portion of a diet—*i.e.*, of those constituents, including the fats, which had hitherto been classed amongst the fats on account of their similarity in physical and solubility characters and their association with chemical groupings characteristic of the known fats. Growing improvements in the technique of biochemistry have simultaneously resulted in a more detailed study of the part played by carbohydrates and minerals in the animal economy.

We are, however, in the present discussion, concerned not so much with the destiny and function of the numerous chemical compounds which at the present day represent the sub-divisions in the classification of the earlier physiologists, as with the conditions arising when any essential one of them is missing. That is to say, we are concerned with the problem of "dietetic deficiency."

We need not discuss in detail the gross deficiency of all food which leads to death by starvation; nor protein-hunger, which may be regarded as a form of delayed general starvation; nor need we deal with the abnormal conditions arising on a diet of pure fat where both protein and carbohydrate are excluded from the food. The problems associated with mineral deficiency must also be left aside except in so far as incidental reference requires. Mineral metabolism is still on speculative ground, but we know of no clear case of specific disease arising through any but the grossest omission of essential inorganic constituents.

Theoretically, any mineral constituent required in the construction of any animal tissue must of course be present in the food in adequate amount, and insufficiency may give rise to a generalised malnutrition, or to a specific set of pathological symptoms clinically recognisable as a specific disease, or to both. As a passing example of the effects of gross omission of an important mineral constituent from a diet, we may quote the following figures* of some recent feeding experiments where maize grain, which is notably deficient in calcium salts, was used as main component of the food.

1. *Calcium-rich Diet.*	2. *Calcium-poor Diet.*
90 per cent. Maize.	Same diet without chalk.
10 per cent. Gluten Meal, plus chalk	
($CaO = 0.448$ per cent.)	($CaO = 0.055$ per cent.)

* Weiser, *Biochem. Zeitschr.*, July, 1914.

At the commencement of feeding, three pigs on Diet 1 together weighed 17.7 kgs., and three pigs on Diet 2 weighed 17.6 kgs. Six months later the total weights were 41.8 kgs. and 36.8 kgs. respectively—i.e., the pigs on the diet to which chalk had been added had gained 135 per cent. as against 110 per cent. for those on the calcium-poor ration, the quantity of food eaten being the same in each case. Dried blood was then substituted for gluten meal (leaving the calcium content practically unaltered), and the pigs weighed separately. At this time pig No. 1, on the calcium-rich diet, weighed 17.9 kgs., and pig No. 4, on the calcium-poor diet, 13.5 kgs. Three months later No. 1 weighed 35.7 kgs., *i.e.*, practically double. Pig No. 4, on the other hand, decreased in weight to 12.6 kgs., steadily losing appetite and refusing to eat an adequate amount of food. The animals were then killed, and their bones analysed:—

	Pig No. 1.	Pig No. 4.
Character of bones	Normal	Thin, deformed, soft flexible.
Weight of fresh Skeleton ..	2.675 kgs.	1.612 kgs.
Weight of fat-free dry skeleton	1.198 kgs.	0.592 kgs.
Water content of skeleton..	46.59 per cent.	57.41 per cent.
Mineral matter of fat-free dry skeleton	48.40 per cent.	40.03 per cent.
Lime in fat-free dry bones—		
Skull	33.14 per cent.	30.01 per cent.
Ribs	23.75 per cent.	13.88 per cent.
Fore-legs..	25.21 per cent.	18.87 per cent.

From these figures it is seen that on the calcium-deficient diet the animals suffered in general health and failed to grow normally, more especially in the later stages of the experiment. The growth of bone was notable restricted and calcification was defective. The simple addition, in the form of chalk, of the missing calcium sufficed to allow of comparatively normal development.

The deficiency here may, in the main, be regarded as of a relatively simple kind. The calcium salts actually required for normal metabolism are absent from the food, and calcium-starvation ensues, bringing with it not merely a pathological condition of the bones where the demand for calcium is highest, but also a general disturbance of bodily function and development Where deficiency in lime is less acute it may *perhaps* happen that the only serious disturbance is that of bone metabolism. The converse case, however, by no means holds. Thus a general malformation and defective calcification of the bones does not necessarily indicate a deficiency of calcium in the diet. As illustrating this we have the two diseases osteomalacia and rickets, both of which are associated with defective bone structure, and yet both of which may occur on diets containing a large excess of calcium compounds. In such cases the pathological condition of the bones is an effect of the disease, whereas in the former case of calcium-starvation the dietetic deficiency is the cause. This distinction

is of the utmost importance, since many diseases have from time to time been regarded as causally related to a lack of minerals in the diet simply because the disease affected the bones. Thus in South Africa, for instance, the so-called "osteoporosis" in horses is commonly regarded as due to dietetic deficiency, whereas it is much more probable that it is of purely infectious origin.

Without going into the details of the starvation condition arising when there is gross deficiency in the "*energy value*" of a diet (*i.e.*, for practical purposes, a lack of carbohydrates and fat), or where there is a marked deficiency in the protein content, it may be mentioned that life may be indefinitely maintained on a diet which is appreciably below the normal requirements of a healthy animal. A half-starved condition or state of general ill-nutrition then results, and the organism is incapable of the normal "effort" in response to demand.

As an illustration of imperfect nutrition on a diet which lies very near the normal, but is deficient for the purpose in view, we may take a case in which all the necessary food-constituents are present in fair amount, and in which the dynamic requirements of the animal concerned are fully satisfied, but in which the components are differently balanced. Suppose a ration for dairy cows in full milk be made up from silage, clover-hay, gluten meal, and maize. Suppose that the gross energy requirements calculated from the size and class of the animals be set down at 18,000 calories per day—

	Ration I. lbs.	Ration II. lbs.
Maize Silage	30	30
Clover Hay	8	5
Gluten Feed	4.66	3
Ground Maize..	3.33	8
Corresponding to—		
Digestible Protein..	2.22	1.93
Digestible Fat.	0.40	0.51
Digestible Carbohydrate	11.7	13.0
Energy value..	18,524 calories	21,130 calories

These two rations, which happen to be experimental diets in certain American feeding trials, contain the same components, but in different proportions. A batch of cows on Ration 1 throve well. A batch on Ration 2 lost in condition in spite of the higher energy value of their diet, and gave a milk yield of approximately one-third less. So far as one can judge from the diets, the difference is to be attributed to the difference in protein content, which in Ration 2 (0.29 lb. less) was inadequate to meet the demands of the cows in milk. Here we have a deficiency which, next to starvation, is the simplest in type. It represents a mild form of protein starvation, resulting in loss of condition, but not resulting in disease. The ration given would not have been deficient for store cattle.

Suppose now that a diet be selected which is adequate in respect both to energy requirements and to mere quantity of

protein. Wheat has a comparatively high protein content, and by supplementing mineral deficiency with inorganic salts a diet may be readily constructed which at least fulfils the usual text-book conditions of dietetic sufficiency. Yet within the last few years several papers have appeared in which experimental evidence is adduced to show that an exclusive wheat diet is inadequate for the normal growth and reproduction of animals. Hart, McCollum, and Steenbock maintain that wheat alone does not allow of normal reproduction in herbivora, but leads to weak and under-sized offspring, while an addition of maize to the ration allows of a normal reproductive cycle.

As an illustration of the effect on *growth* of a diet restricted to the products of the wheat grain, the following figures of Hart and McCollum* may be cited, parallel data for maize being given for comparison.

DIET.

Ration II.		Ration IV.	
Wheat meal	$97\frac{1}{2}$ per cent.	Maize meal	70 per cent.
Wheat gluten	$2\frac{1}{2}$ per cent.	Gluten feed	30 per cent.
		plus salts.	plus salts.

Date.	Weight of Pig No. 7. lbs.		Weight of Pig No. 3. lbs.
March 11th	44	....	49
April 22nd	68	....	63
June 17th	82	....	82
July 8th	89	....	89
September 30th	92	....	142
October 28th	86	....	171

In both cases the protein content of the ration was as high as 14 per cent. Growth on the maize products was normal, but the growth *failure* on the wheat ration was most marked. No complete explanation of the difference can be given (the authors suggest "toxity in wheat kernel"), but in the experiments cited the substitution of 2½ per cent. of casein for the 2½ per cent. of wheat gluten sufficed to induce normal growth.

Osborne and Mendel, in 1914, showed that if pure gliadin—*i.e.*, the principal protein of wheat—be fed to young rats as exclusive protein in the diet, growth is restricted irrespective of the amount given. They have also shown that rats do not grow on a diet consisting of certain pure isolated proteins along with starch, lard, and protein-free milk. If, however, the lard is replaced by butter, or if a little whole milk be added to the diet, the symptoms of ill-health (diarrhœa) disappear, and normal growth is maintained.

Other investigators have obtained analogous results, certain of which will be discussed presently.

If we accept the experimental evidence as sound, we have here two types of deficiency suggested:—

(*a*) A deficiency arising from the kind or the quality of the protein irrespective of its quantity;

* *Journal of Biological Chemistry*, November, 1914.

(*b*) A deficiency which is not attributable either to the protein fed or to possible lack of suitable mineral components, since the simple substitution of lard by butter sufficed to correct the deficiency.

Deficiency in the Kind or Quality of Protein.—Carl Voit, Panum and Oerum, and others, long ago recognised that a marked difference existed between gelatine and other proteins, and had shown that gelatine was incapable of functioning as *sole* protein in a diet, although it could to a large extent replace or "spare" the catabolism of other proteins. Munk, for example, found that with dogs on a mixed diet not quite four-fifths of the total protein in the ration could be replaced by gelatine.

To understand such facts, it is necessary to consider the constitution of the protein molecule. As already mentioned, the proteins, however complex in themselves, may be broadly regarded as compounds built up mainly of comparatively simple amino-acids. Up to the present time at least 18 different amino-acids have been definitely determined as protein units. These are: glycine, alanine, valine, leucine, isoleucine, phenylalinine, tyrosine, serine, cystine, aspartic acid, glutamic acid, arginine, lysine, caseinic acid, histidine, proline, oxyproline, and tryptophane.

Any given protein may contain all of these or few of them. Thus nearly all are to be found in the proteins of blood, whereas silk fibroin, the simplest protein known, is supposed to contain only three—glycine, alanine, and tyrosine. The simplest protein molecule, however, contains a very large number of amino-acid units, even if they be few in kind. In some proteins one particular amino-acid may preponderate very largely over all others. Thus, for instance, the *salmine* of fish sperm contains over 80 per cent. of arginine, and is therefore built up chiefly of this one amino-acid, although others, such as valine, serine, and proline, are also present. The proteins of leguminous seeds, such as beans and peas, most nearly approach muscle protein in composition, and this is probably the explanation of their high value as food-stuffs.

To return to the gelatine feeding experiments. Investigation of this particular protein has shown that three important amino-acids are missing—tyrosine, cystine, and tryptophane. If these three units be isolated from other sources and added to a diet containing gelatine as sole protein, it is now found that life and tissue-equilibrium can be maintained—for short periods, at least. Thus Kaufmann brought himself into nitrogenous equilibrium on a diet in which caseinogen was the protein contained, and then found that if he replaced the caseinogen nitrogen by nitrogen from gelatine 93 per cent., tyrosine 4 per cent., cystine 2 per cent., and tryptophane 1 per cent., the mixture practically sufficed to prevent loss of body protein.

The experiments of Hopkins and Willcock in 1907 with *zein*, one of the proteins contained in maize, yielded evidence

similar to that of the gelatine feeding experiments. Zein contains no tryptophane in its molecule, although some of the other maize proteins do. Mice were fed on a mixed diet, in which, however, zein was the only protein present, and it was found that 77 per cent. of the mice died within 20 days. The addition of tyrosine to the diet produced no effect, but after the addition of the missing trytophane the mice lived much longer, and showed a much better physical condition.

Results such as these are easy to understand when we remember that the higher organisms probably cannot synthesise their own amino-acids to any appreciable extent, but must receive them, or most of them at least, ready-made in their food; and, further, remember that the composition of animal tissues is constant and, broadly speaking, incapable of varying in response to differences in the composition of the food eaten. The so-called "law of the minimum" finds a simple application here, and the protein demands of an animal are seen to be conditioned not so much by the gross quantity of protein eaten as by the quota of those necessary units contained in smallest amount within the protein molecule.

To return now to the recent experiments of Osborne and Mendel. These authors are of opinion that amino-acids containing cyclic nuclei can never be synthesised *de novo* by the animal cells as they are in plant life, and hence that proteins poor in units such as tyrosine, tryptophane, and lysine, are of inferior value as foods, especially during growth where new tissue-proteins are being formed. Trytophane is credited with playing a unique *rôle* in preserving *maintenance*, and is contrasted with lysine, which is regarded as indispensable for *growth*. In one series of experiments Osborne and Mendel added lysine to their previous zein-feeding mixtures, and for the first time successfully reared (not merely maintained) rats on a diet containing zein as sole protein.

With these few illustrations of dietetic adequacy or inadequacy in respect to the protein moiety of a food we may pass on to the question of deficiency of the second type.

Deficiency of Substances Mechanically or Chemically Associated with the Lipoids.—If a feeding composite be extracted with certain organic solvents, a fraction is obtained which, for want of a better name, is slumped under the term "lipoid." This fraction may contain the true fats, the lipines—*i.e.*, bodies analogous to the fats, but containing phosphorus or nitrogen, or both (*e.g.*, lecithin), bound up with fatty-acid groupings; phytosterol or cholesterol derivatives, waxes, essences, and numerous other bodies. The quantity and nature of the lipoid fraction depends on the material extracted and on the solvent used. It is not necessary to go into the classification of this group here; suffice it that the substances concerned are numerous, and in many cases not yet clearly defined, either chemically or physiologically. It will be sufficient to discuss a number of cases in which the absence of

certain substances mechanically or chemically associated with the lipoid group, gives rise to dietetic insufficiency.

So far back as 1881 Lunin described experiments in feeding mice upon a synthetic diet of caseinogen, fat, cane sugar, and the ash of milk, and showed that, in spite of the abundance of both protein and non-protein in the food, the mice died in from 20 to 31 days, whereas if fed upon simple dried milk they were still alive at the end of 2½ months In 1896 Hall carried out similar experiments with similar results; on the artificial diet the mice died within 40 days, although they fed greedily at first. The experiments of Lunin attracted considerable attention, and in the light of knowledge current at the time were capable of explanation in several ways. They established a marked difference between the dietetic efficacy of dried milk, and a ration simulating it in all gross particulars. They did not, however, allow a decision to be made as to whether the lacking factor was organic or inorganic. There was no guarantee that the ash of milk supplied the necessary inorganic constituents in suitable form of combination, while on the other hand, there was no evidence to show that any specific forms of chemical combination within the mineral moiety of a diet were necessary.

Röhmann in 1902 fed mice on so-called pure diets, but with greater variation, and found that his animals remained healthy for much longer periods. Unfortunately his synthetic diets were far from pure, and his suggestion that various proteins might vary greatly in nutritive value, although subsequently shown to be correct, had probably no real bearing on his belief that the negative character of the earlier experiments on synthetic diets was due to variation in the nature of the protein fed.

At this time very little was known concerning the true nature of the deficiency, and Knapp, even in 1909, on the results of experiments with rats on a diet containing seven dfferent varieties of pure proteins together with cholesterol, lecithin, carbohydrate, fat and salts, in which the animals died in from 9 to 16 weeks, could offer no adequate explanation of the insufficiency. He further found that on a fat-free horse-flesh ration there was a tendency to early death. This observation is in accord with the suggestion of Stepp, made in the same year, that the failure to maintain life on artificial diets was due to a lack of "lipoid" extractable from food by organic solvents. Stepp showed that mice fed on milk bread throve perfectly well, but that after extraction with alcohol and ether the milk bread no longer sufficed to maintain life. The restoration of the extracted lipoids to the extracted diet partially restored its maintenance capacity, although comparison with controls on unextracted bread suggested loss or destruction of some important lipoid constituent during the process of extraction.

Hopkins in 1906 had already suggested that certain materials taken in the food were essential to the organism without actually

contributing to the formation of tissue, and in 1912 Hopkins and Neville published results analogous to those of Stepp, in which they emphasised the importance of the alcohol-soluble fraction of a feeding composite.

The general position, then, a few years ago, may be summarised by saying that the dietetic significance of certain "minimum substances" was recognised; which substances might either be lipoid in character, or nitrogenous bodies containing nuclei like those occurring in the amino-acids of proteins.

While all this work on feeding problems was proceeding—*i.e.*, from about the beginning of the present century onwards—a great deal of research was also being carried out upon the nature of certain obscure diseases, notably beriberi, the origin of which appeared to be traceable to dietetic deficiency of a specific kind. About 1912 Casimir Funk introduced the name "vitamine" to denote a specific class of food constituent, the absence of which in an otherwise normal diet involved metabolic disturbance resulting in malnutrition or in specific disease.

"The "vitamines" belong to the group of "accessory" or "minimal" substances already mentioned, which are almost invariably present in all ordinary foods, but which under abnormal circumstances may be absent. Within the last few years Funk has made a special study of these substances, and done a great deal towards elucidating their chemical nature. To a condition resulting from a vitamine deficiency he applies the term "avitaminosis," and within the category of such diseases he brings either definitely or tentatively:—

(1) The Beriberi group, including polyneuritis in birds.

(2) The Scurvy group, including Barlow's disease.

(3) Pellagra (and Sprue).

(4) Rickets and Osteomalacia.

(5) Diseases known in Germany as "Mehlnährschaden" and "Milchnährschaden."

(6) Lamziekte and stijfziekte in cattle.

Under a final heading he also discusses the vitamines in relation to growth, to the problem of cancer and tumour growth, and to various problems of plant and animal metabolism.

It would occupy too much of your time to present all the aspects of avitaminosis as raised by Funk,* and since much of his discussion, though in itself very illuminating, is speculative, we may first confine our attention to those instances of vitamine-hunger in which the evidence is clearest.

Beriberi.—It was in the study of this disease that the experimental evidence ultimately crystallising in the conception of vitamine-hunger was chiefly obtained. The malady occurs mainly in tropical and subtropical zones, and almost exclusively amongst rice-eating peoples. Particularly during the last quarter of a century it has excited enormous interest, and yet until recently

* "Die Vitamine, ihre Bedeutung für die Physiologie und Pathologie." (1914).

remained a mystery, in spite of strenuous research carried out from the bacteriological and pharmacological points of view. The apparently epidemic character of the disease naturally suggested a causal organism, although equally naturally any disease becomes epidemic whenever large number of sensitive recipients are exposed to a common causal environment, irrespective of the nature of the cause. Toxic agency was also conjectured, and much fruitless labour was expended in seeking for the toxin. Even to-day eminent adherents both to the infection and to the intoxication theories are to be found, and even so recently as last year Abderhalden, of Halle, and Caspari, of Berlin, expressed the opinion that the case for the "deficiency theory" as against the "intoxication theory" was by no means proven. At the same time the evidence in favour of the vitamine-hunger theory is strong enough to have convinced the majority of investigators that *true* beriberi is to be regarded as the clearest existing case of a deficiency disease.

A brief historical *résumé* of the main lines of investigation as reviewed by Funk, and others, may be given.

Wernich, (1878) and Van Leent (1880) are stated to be the first investigators who connected beriberi (kak-ké) with the consumption of rice, and in 1882 Takaki (working on the idea of protein deficiency) effected an enormous reduction in the beriberi mortality in the Japanese navy by the empirical introduction of a mixed diet in place of the earlier rice ration.

Vordermann, on the basis of statistical evidence collected from Japanese prisons in 1895-96, at the suggestion of Eykman, clearly demonstrated a close connection between the occurrence of the disease and the prolonged consumption of *polished* rice. Braddon confirmed this work in the Malay Peninsula, and observed that the Tamils, a class of natives who generally use *unpolished* rice, remain free from the disease.

The clue to the connection between the polishing of rice and the occurrence of beriberi was in part suggested by the extraordinary increase of the disease which followed upon the spread of European culture in the East, towards the end of the nineteenth century. The extensive importation of high-grade European machinery during this period led to a higher degree of refinery of general milling products. More particularly the cleaning and de-branning of rice which had previously been imperfectly carried out, chiefly by crude hand-mills, was now performed by subjecting to an extremely thorough mechanical polishing by leather straps. This effected a practically complete removal of the outer layers of the grain, and with them, as subsequent research showed, certain physiologically essential compounds located on the exterior of the kernel—the "vitamines."

Before passing on to a sketch of the work carried out in connection with the chemical nature of the vitamines, it may be of interest to indicate the clinical and pathological findings of beri-

beri in the human subject and "experimental beriberi," or *polyneuritis gallinarum,* in birds.

In the human, four main forms of the disease are usually distinguished, although combinations of the type forms may occur.

(1) The *mild sensory-motor or ambulatory form* is said to be the most frequent, and to be commonly precipitated from the dormant state by over-exertion. The patient shows signs of weakness and uncertainty in the legs, and the calf muscles are sensitive to pressure. Sometimes œdema in the lower limbs is observed, and palpitation of the heart after exertion is common. The knee reflex is at first intensified and subsequently weakened. Temperature is normal.

This form, if free from complications, is easily cured by rest and simple change of diet.

(2) The *dry atrophic form* involves muscular atrophy and gradual paralysis, usually affecting first the legs, then the arms and hands, and finally the trunk muscles. This form is also curable, and complete recovery is possible within a few months. Relapses, however, frequently occur, and often the cure is not complete. Chronic cases, involving permanent contractures of the feet, and sometimes of the fingers and biceps, may also occur. These appear to be no longer curable, and the patient is reduced to crutches.

(3) The *dropsical atrophic form,* sometimes diagnosed under the name "*epidemic dropsy,*" is said to be characterised by disturbance of the circulatory system in addition to showing symptoms analogous to those just mentioned. Tachycardia, dyspnœa, oliguria and indicanuria, œdema, hydropericard, and pleurohydrops, appear to belong to the symptoms of this form. Paralysis of the larynx, diaphragm, intercostal muscles, and less commonly of the brain nerves, may occur. Death is usually attributed immediately to vagus paralysis. This dropsical form is common in puerperal beriberi. In cases not too far advanced cure may be effected, and if so, is accompanied by diuresis and rapid disappearance of the œdema, whereupon the true muscular atrophy becomes apparent.

(4) The *acute or cardio-vascular form.* This variety arises either primarily, or from one or other of the already-mentioned forms—either spontaneously or following over-exertion. It may appear quite suddenly, and even within a few hours very serious symptoms may develop—precordial distress, epigastric pain, dyspnœa, tachycardia, nausea, vomiting. The temperature remains normal and consciousness clear. The heart becomes enlarged, particularly the right ventricle, and the whole heart region pulsates in consequence of increased heart labour and paresis of the intercostal musculature. The pulse is increased to 120, and even to 140 in severe cases. Respiration is asthmatic. The voice is often hoarse or altogether lost. The urine gives a marked indican reaction, weak albumen reaction, and sometimes the diazo reac-

tion. Death almost invariably supervenes within a few weeks, sometimes within a few days or even hours—with frequent pulse, cyanosis, and œdema of the lungs.

Post-mortem Appearances.—Those described naturally deal with the most acute cases, and may include, singly or combined, œdema of the skin and musculature, cyanosis of the extremities, lips, and ears, subcutaneous hæmorrhage, hydropericard, hydrothorax, ascites, ecchymosis of the stomach and duodenum, dilation and hypertrophy of the heart with fatty degeneration of cardiac muscle, œdema of the lungs, and minor changes in the kidneys and other organs. The most important changes are said to be those of the muscles and peripheral nerves.

Microscopically all stages of nervous degeneration may be evidenced. In fresh cases the number of degenerated fibres is small, and at the nerve endings those fibres adjacent to degenerated muscle fibres seem to show the most alteration. The degenerative neuritis is said to concern chiefly the peroneal, tibial, and saphenous nerves of the legs, ulnar, radial, and median of the arms; also the phrenics and the vagi. The whole nervous system, however, is probably affected.

Affected muscles show all stages of degeneration and atrophy, the first indications being a growing indistinctness of the cross striation.

Polyneuritis gallinarum, or experimental beriberi in birds, is regarded as closely related to human beriberi. Since the study of this disease, artificially produced by Eykman in 1897, and subsequently studied by innumerable other investigators, has done so much to clear up the question of beriberi proper, brief reference to it may be made.

Two main types occur in pigeons.

(1) *Acute Form.*—To begin with, a general lowering of activity is evident in which the bird shows disinclination to move, and if disturbed runs a short distance and evidences exhaustion by making use of its wings without definitely attempting to fly. This latent manifestation is not always recognisable, unless, or until, it passes over into the acute form proper, in which there is general incoherence of movement, more especially of the head, or contraction of the neck muscles resulting in a characteristic twisting back of the head. Mere handling, as in cramming, is often sufficient to bring about a sudden transformation from latent to acute form, and when this happens the neck is usually twisted back, the legs are drawn up, and the bird rolls head over heels backward—a rolling which may go on continually or intermittently for hours on end, unless restricted. The course of the acute form is rapid, and the bird usually dies within 24 hours, although, as we ourselves have observed, spontaneous recovery may occur if the bird is starved. A second attack, however, almost immediately ensues if the bird is again fed on the causal diet. Minor variations of this most distinct form may occur, and for pigeons hand-fed on about one-twentieth of their own weight

of polished rice per day an attack is usually developed in about three weeks.

(2) *Chronic Form.*—The bird sits motionless in its cage, and seldom moves unless compelled to. Finally the locomotor functions may even be entirely lost. This form is not so easily distinguished as the first.

Associated with both forms is a marked drop in weight—the more marked, the longer the bird survives. In acute cases coming on early the drop may only be 10 per cent. or so. In chronic cases it may be as high as 50 per cent. In both forms death ensues if rigid adherence to the causal vitamine-poor diet is observed.

Eykman recently (1913) stated that he had observed recovery in pigeons after the injection of the mixed chlorides of sodium and potassium, but as we ourselves have observed similar *temporary* recovery following the injection of water, we consider such recovery to be spontaneous.

Both forms are curable by simple administration of vitamine extracts either *per os* or subcutaneously, and if the bird shows temporary spontaneous recovery it may be rapidly restored to complete health and original weight by change of diet to foodstuffs rich in vitamine. The acute form is most easily cured, and in an astonishingly short time. A bird may be on the verge of death and yet be restored to apparently healthy condition within a few hours by the injection of vitamine extract.

In birds the nervous degeneration observed after death from beriberi is usually very characteristic.

Chemical Nature of the Curative or Preventive Substances.—To Eykman (1897) belongs the credit of the pioneer work. He found that the rice polishings, or pericarp and subpericarpal layers of the grain, possessed the power of preventing the outbreak of polyneuritis in birds fed upon polished rice. He, however, explained his results on the supposition that a toxin was developed from the starch of the grain which acted injuriously on the nervous system, and that the toxin action was prevented by some antitoxic body present in the pericarp.

Eykman also observed (1906) that an aqueous extract of rice polishings possessed curative properties.

Frazer and Stanton showed that the active curative principle of rice polishings was soluble in alcohol, and remained in solution after all proteins were precipitated. They carried out analyses of different samples of rice, and showed that a certain empirical relationship existed between the phosphorus content and the curative constituent, suggesting an indicator limit of 0.4 per cent. P_2O_5. Rice containing more than this amount of phosphorus was regarded by them as safe for sole consumption, without danger of beriberi.

About the same time Gryns confirmed Eykman's earlier work, and suggested that the cause of the disease was deficiency of some substance necessary for nerve metabolism. He also

found that on heating to 120 degrees Centigrade the curative or preventative principle was destroyed, and he established its presence in other food-stuffs, notably beans.

Bréaudat in 1901 used rice polishings therapeutically in the treatment of human beriberi, with considerable success.

Supported by the work of Frazer and Stanton, Schaumann in 1908 put forward the theory that deficiency in organically-combined phosphorus was the cause of beri-beri.

In 1910 he found that yeast was particularly rich in the curative substance, and in 1912 Thompson and Simpson reported successful utilisation of yeast in beriberi therapy. Eykman and Funk about the same time showed that the active principle could to some extent be extracted from yeast by 88 per cent. alcohol, although Funk points out that the extraction is very imperfect.

Teruuchi in 1910 obtained an alcohol-soluble product from rice polishings which contained comparatively little phophorus, thus militating against the phosphorus deficiency theory of Schaumann.

As to the state of knowledge in 1911, Funk summarises the position by saying that little was known beyond the fact that the curative substance was soluble in water and in alcohol, was dialysable, and could be destroyed by heating to 130 degrees Centigrade. From this time onward a steady stream of papers appear in various English and German journals under Funk's name, bearing upon the chemical and physiological behaviour of curative extracts prepared from various sources. He finally disposed of the phosphorous deficiency theory by isolating, from rice polishings, a curative fraction entirely free from phosphorus.

By extracting with acid alcohol, lixiviating the evaporated extract with water, precipitating with phospho-tungstic acid, decomposing the phosphotungstate with baryta and removing the barium, he finally obtained a highly curative fraction in crystalline form. The yield was extremely small—about half a gram per cwt. of rice polishings. A few milligrams sufficed to cure polyneuritic pigeons in a few hours.

Since then he has described a series of fractionings from rice polishings, including cholin, betaine, nicotinic acid, and a crystalline vitamine to which he assigns the empirical formula $C_{26}H_{20}N_4O_9$. From yeast he has isolated a vitamine to which he assigns the formula $C_{24}H_{19}O_9N_5$.

Other investigators have also isolated comparatively pure crystalline fractions from rice polishings, but in a less definite form.

According to Funk, the vitamines isolated by him are closely related to the purins and pyrimidins.

The difficulty in determining their constitution lies in the difficulty of obtaining quantities sufficient for investigation.

Other Deficiency Diseases.—Considerations of space do not permit of an equally detailed *résumé* of other diseases for which vitamine deficiency has been held responsible.

Scurvy, the earliest of the diseases recognised as dietetic in origin, has been long regarded as a type of "deficiency disease" arising wherever a supply of *fresh* food became unavailable. It was most prevalent amongst sailors on long sea voyages in the old sailing vessels, and victims which survived to reach port were found to be curable by change of diet to foods such as vegetables, fresh meat, fruit and fruit juices. So far back as 1795 a lime-juice ration was introduced into the English marine service as a preventative measure against scurvy. In the first Scott Expedition to the South Pole an outbreak of scurvy occurred, but this disappeared again as soon as fresh seal meat became available.

The theories in regard to the causation of scurvy have been various. The phosphorus deficiency theory of five or six years ago has now given place to the avitaminosis hypothesis, and scurvy is now regarded as due to the lack of a vitamine, analogous to the beriberi vitamine, but more easily destroyed, and therefore more likely to be lacking in preserved foods.

Barlow's Disease, or infantile scurvy, has been attributed to the use of sterilised milk and artificial "baby-foods."

Pellagra, a disease characterised by erythema, stomatitis, gastro-enteritis, and degenerative alteration of the central nervous system, and occurring chiefly in the countries where maize is the staple cereal, is held by Funk to be associated with the consumption of maize in much the same way as beriberi is with that of rice. The disease is most prevalent in Northern Italy, Roumania, Southern Tyrol, and Northern America.

Several other hypotheses have been put forward to account for its occurrence, including an intoxication theory, an infection theory, a "photodynamic" theory, in which the malady is held to be due to an increased sensitiveness to light on the part of the patient, brought about by the presence of toxic light-sensitising bodies in spoiled maize, and, most recently of all, a rather vague theory which attributes pellagra to the presence of collodial silica in the drinking water.

On the whole, the evidence for any one theory is not conclusive, and at the present day the infection theory still seems to claim the majority of adherents.

Rickets and Osteomalacia.—For these two diseases, in which bone lesions present one of the most characteristic features of the trouble, the vitamine-hunger theory has also been advanced. The supporters of the theory are, however, few as yet, and we may therefore omit these diseases from the discussion.

Within the last few years the vitamine hypothesis has been boomed to such an extent that a tendency is sometimes shown to bring as yet unexplained diseases within the category of the avitaminoses, whether the evidence really justifies it or not.

One of the difficulties in the way of explaining a variety of diseases on the same hypothesis lies in the fashion in which the hypothesis has to be stretched beyond the experimental evidence which gave it birth. In the case of the vitamine theory, the

varying nature of the different maladies to which the same type of animal (man) is subject, suggests a variety of vitamines.

Why should vitamine-hunger manifest itself in different ways—as beriberi, scurvy, pellagra, rickets, osteomalacia? Until more definite evidence is available regarding the precise circumstances under which each disease occurs, we are not entitled to assume that there are several distinct and separate vitamines each (when lacking) responsible for a different set of symptoms. At the same time there is evidence that different vitamines exist, and that the absence of these may manifest itself in different ways.

A complete food contains all the constituents necessary for health, growth, and reproduction, and any train of pathological symptoms arising from a dietetic deficiency may arise through a lack of either a single constituent or a group of constituents.

Variety in the nature of vitamines is indicated by the observation that substances protective against scurvy are much more easily inactivated than those protective against beriberi.

The antiscorbutic vitamine may often be destroyed by the simple desiccation of substances containing it, while the beriberi vitamine is not only more stable towards heating, but, as its presence in dried grains indicates, need not be seriously affected by drying. The distinction is further indicated by the observation of Holst (1911) that peas only protect guinea-pigs against scurvy after germination, and of Fürst (1912) that the oat grain, on germinating, develops an antiscorbutic substance which was previously lacking. Yet both oats and peas contain the beriberi vitamine, and Funk makes the interesting suggestion that the beriberi vitamine is the comparatively stable form in which storage in the grain occurs, and that during germination the beriberi vitamine is transformed into the most labile scurvy vitamine concerned with the active physiological functions of the plant. The antiscorbutic vitamine protects against both scurvy and beriberi, but the antiberiberi vitamine does not protect against scurvy.

Funk has also recently (1914) shown that a diet of red rice, fed to fowls, prohibits growth without, however, inducing polyneuritis.

How many different vitamines there may be is still a matter of speculation. As yet, however, there is no clear evidence for supposing that the maize vitamines are sufficiently different from the rice vitamines to account for the difference between pellagra, which is credited to a lack of some constituent in the milled products of the former cereal, and beriberi, which is established for the polished grain of the latter.

Apropos of the use of milled maize as main native diet on the Rand mines, we may mention that pellagra has not yet been reported in Johannesburg, and that although cases of scurvy, and scurvy of the beriberi type, are far from unknown, they represent a very small statistical proportion of the total native

labour employed. The natives, of course, are not fed upon highly milled products, and although we have ourselves fed considerable numbers of pigeons exclusively upon the native meals, we have been unable to produce polyneuritis.

At the same time there is no doubt that the vitamines of maize are located in the grain in much the same way as they are in rice, *i.e.,* in the external layers. We have produced polyneuritis in pigeons fed upon "samp" (rasped mealies) in as short a time as on polished rice, and have satisfied ourselves that at least the high-grade milling-products of maize (table meals) are deficient in vitamine. The deficient character of such preparations is, however, of little practical consequence, since the highly milled preparations, being more expensive than the crude meals, are only used by well-to-do people, whose diet is sufficiently varied to ensure an ample vitamine intake from other sources.

Lamziekte.—This disease of cattle, peculiar, so far as is known, to South Africa, but representing, now that rinderpest and East Coast fever are well under control, the most serious problem of the stock-raising farmers of the country, has also been maintained to be an avitaminosis.

Deficiency theories of lamziekte have been on the South African market for a long time, and it is interesting to note that these have followed the prevailing fashions. The earlier calcium and phosphorus deficiency hypotheses correspond to the earlier theories for rickets, and for scurvy and beriberi. Lastly, the conception of vitamine-hunger was put forward by Funk in London, and, very enthusiastically, by Stead in this country.

Theiler, in his last "Report of the Director of Veterinary Research," (1912) discountenanced the idea that lamziekte was a deficiency disease, and, without specific reference to the vitamines, argued on general grounds that "lack of nutrition" failed to explain the facts observed in connection with the disease. At the same time many of the observations discordant with such a theory were not specifically experimental in character, while the view expressed by certain farmers that the disease was less prevalent amongst cattle not confined exclusively to veld pasture left legitimate room for difference of opinion. The question was therefore again taken up experimentally by the Veterinary Research Division, and the vitamine hypothesis subjected to direct test.

As applied to lamziekte, the hypothesis expressed by Funk is that the vitamines naturally present in the grass on affected areas are destroyed by long-continued drought, and that, as a consequence, vitamine-hunger arises in cattle exclusively fed upon the parched pasture. He drew an analogy between lamziekte in the bovine and beriberi in the human, and suggested that lamziekte belonged to the beriberi class of deficiency diseases. He therefore advised that yeast be tried as a prophylactic measure.

We do not propose to go into the details of the experiments of the Veterinary Research Division on the subject, since these

are already in course of publication,* but a brief outline of the work may be of interest here.

The main scheme of experiment in so far as it bears on the avitaminosis aspect of lamziekte may be indicated:—

(*a*) An attempt was made to produce an avitaminosis in cattle by feeding on a known deficient diet. For this purpose polished rice was used, along with an extremely small ration of veld hay or autoclaved straw, so as to minimise digestive disturbance. If a recognisable disease had been produced, it could have been compared symptomatically with lamziekte. No specific disease was manifested, however, even after a full year of rice feeding, and from this it was concluded that if an avitaminosis exists in cattle at all, it must be a matter of very slow development. This was also accepted as evidence against the probability of lamziekte being an avitaminosis, since fresh cattle from a non-lamziekte area may, when brought on to an affected area, develop the disease in much less than a year.

(*b*) Feeding experiments with pigeons were carried out to determine the antiberiberi value, or vitamine content, of a number of feeding stuffs which were fed as supplementary rations to cattle on lamziekte veld.

(*c*) Cattle grazing naturally over lamziekte veld were supplied with rations containing vitamines in large excess of their probable metabolic requirements, calculated on the basis of the pigeon tests. The beriberi vitamine was supplied in the form of beans, bran, maize, and yeast. The scurvy vitamine was given in the form of raw potatoes. The rate of mortality was then compared amongst cattle which had received supplementary feeding and cattle which merely grazed on the lamziekte veld. No difference was apparent, and it was therefore concluded that lack of vitamine was not the cause of lamziekte.

(*d*) Vitamine extracts which were found highly curative for pigeons suffering from "experimental beriberi" were administered to cattle suffering from lamziekte. In no case could a cure be effected. This was regarded as evidence confirming the results of the feeding experiments.

(*e*) The rainfall and state of the herbage on the veld was noted during the experimental period. Lamziekte occurred even after heavy rains, when the veld vegetation was green and comparatively luxuriant. This was regarded as disposing of the view that lowering of the vitamine content in the grass, through drought, was causally related to the prevalence of the disease.

From this rough summary of our experimental results, it will be generally agreed that we are justified in concluding that lamziekte is not an avitaminous of any recognised type.

Deficiency Disease in Cattle in General.—Besides our own lamziekte, various other diseases in other parts of the world have

* "Contributions to the Study of Deficiency Disease," Theiler, Green, and Viljoen, Third Report of the Director of Veterinary Research.

been from time to time attributed to dietetic deficiency. "Bush sickness" in New Zealand has been regarded by B. C. Aston (Government Chemist) and C. J. Reakes (Government Veterinarian) as due to faulty nutrition, but, until recently at least, emphasis was laid rather on the idea of mineral deficiency than on that of vitamine-hunger. The evidence, however, for either view, is as yet unconvincing. A number of obscure stock diseases going under such vague names as "dry bible," "coasting," "enzootic paraplegia," "impaction paralysis," and similar non-committal names, have been ascribed to vitamine deficiency by Place in Australia. In England a similar hypothesis has been advanced to account for the difference between adjacent fields in certain areas (notably the Romney Marshes), which show marked differences in the ease with which stock may be fattened upon them, while at the same time showing no marked differences in the character of their vegetation.

A few months ago Henry, writing from Australia, put on record a study of a new disease in the Bega dairying district of New South Wales, explaining it upon the theory of a deficiency of lime and phosphorus in the local vegetation. This Bega disease seems to resemble our own lamziekte in many respects, and it is possible that the two maladies may ultimately turn out to be of similar origin. Meantime, however, we do not regard the deficiency theory for the Bega disease as adequately substantiated by the evidence brought forward, even although that evidence, such as it is, certainly suggests the interpretation Henry offers.

In concluding this cursory sketch of the vitamine aspect of dietetic deficiency, something should be said concerning the physiological rôle of the vitamines in the animal body. Here, unfortunately, we are again on purely speculative ground. It has been suggested that, amongst other things, they supply "mother substances" necessary for the preparation of those secretions of the ductless glands of the body which are now known to play so important a part in regulating the metabolic processes. All that is really known is that they are complex chemical compounds absolutely necessary for the health and growth of most animals. They are only needed in *extremely small amount,* and do not contribute either to the dynamic requirements or to the structural frame-work of the organism. They are pharmacologically indifferent in the sense that an unlimited amount may be taken without ill effect. In so far as the real amount required is concerned, little is known. The pure vitamines have not yet been prepared in quantity sufficient for detailed investigation, but it is known that different individuals, even of the same species of animal, require different amounts, and that the amount which any organism requires is not absolute, but depends upon the amount of food (in the ordinary sense) eaten. The vitamines are in some way connected with the *utilisation* of food after digestion, and the greater the amount of food taken, the greater is the amount of vitamine required. Thus pigeons may be given so little polished

rice that they eventually die of slow starvation without showing any signs of polyneuritis, while if they are given large supplies of polished rice they develop polyneuritis within a few weeks.

Some investigators have advanced the view that the vitamine requirements of an animal are specifically related to its carbohydrate metabolism. In the last resort this may be so, since we have no way of completely excluding the carbohydrate metabolism taking place within the cells of the body. But since we have observed polyneuritis in pigeons on a diet free from carbohydrate, we ourselves are satisfied that there is no specific relationship between vitamine requirements and the *exogenous* carbohydrate metabolism, and that the gross energy intake is the important factor upon which the quantitative demand for vitamine depends.

In concluding this very scrappy essay upon some of the problems of nutrition, we need not be so obvious as to mention that the field for future research on animal dietetics is still a wide one. We may, however, perhaps be permitted to hope that South Africa will contribute as much to the store of human knowledge in this direction as she has already done in others.

RUBBER FROM ALCOHOL.—I. I. Ostromislenskij describes in the *Petrograd Agricultural Gazette* a process patented by him for the preparation of rubber from alcohol. The process comprises two stages. Air is first pumped through the alcohol, and the mixed vapours are passed through copper tubes containing spirals of red copper and silver gauze. The latter are at first heated, but during the subsequent process remain incandescent. Acetic aldehyde and paraldehyde are thus formed. These are now mixed with more alcohol and passed over strongly heated aluminium oxide, producing erythrene, which is collected in an autoclave wherein a small quantity of a catalyst has been placed. Raw erythrene rubber, a pure chemical compound of formula $(C_4H_6)n$, is thus obtained, identical with chemically pure natural rubber, but oxidising more rapidly, so that it is necessary to protect it from atmospheric action and fit it for use in other respects by adding about 15 per cent. of admixtures. These are tannins to resist oxidation, amines, mixed with lead oxide to aid in vulcanisation, and rubber resins, to increase elasticity. This method of synthetic rubber production has been subjected to qualitative and quantitative tests by the Russian Government.

NEW PHOSPHATIC ORES.—According to the *Chemical News**, M. de Rollière, of Paris, announces the discovery of a new ore of high phosphorus content in the granites of France. It is a manganese phosphate, extracted from a blackish brown rock in cleavable masses, and has the following composition:—Phosphoric acid, 33 per cent.; lime, 2.5 per cent.; manganese oxide, 32.5 per cent.; ferric oxide, 32 per cent.

* (1916) **113**, 83.

PRESENTMENT AND PROOF IN GEOMETRY: A STUDY OF THE ASSOCIATED CIRCLES OF A TRIANGLE.

By Rev. Frederick Charles Kolbe, B.A., D.D.

There has been for a long time an earnest endeavour to better the teaching of Geometry. The movement has not, I think, gained quite as much success as many of its enthusiasts had hoped for. If we may judge by the most-used text-books which the movement has produced, there seems to be some mental confusion as to the philosophy and psychology of the subject, or at least there has been some inconsistency in the application of the psychological principles.

1. We must first note a marked distinction in Mathematics itself corresponding to our root ideas of Space and Time. We always remain in physical touch with Space: Time, or Number, tends to become purely abstract. Working with sense-realities and working with symbols are two different processes, and often a mind that loves the one will not love the other. I would almost say that Algebra is *pure* Mathematics, while Geometry is *applied*—quite as much applied as the Theory of the Laws of Motion. Of course Geometry, hand in hand with Algebra, becomes a powerful instrument of symbolic calculation: even the Greeks, having no algebraic notation, made skilful use of it for this purpose, as we see in Euclid's Second and Fifth Books. But this was not the aspect of Geometry that Plato valued for education. It was because it is the first and most fundamental exercise of the idealising power, selecting from Nature and thinking away the complexities and irregularities and imperfections, and so taking the first steps towards that reaching after the One in the Many, the Absolute amid the contingent, the Infinite and Eternal within the limited and transient, which is the work of Philosophy. By its keeping hold of the tangible it goes beyond mere logic: it is, therefore, something more than proofs and puzzles. It is a Knowledge as well as a Process, and my complaint is that the process side of it is exaggerated.

Symbolic calculation, like formal Logic, takes no account of any relation between the contents of its terms. You have to interpret the realities into symbols, and with these you work away with the indifference of a machine. If no error is made, your result will be consistent with the data, and you have then to retranslate it into realities. But the process is often wider

than the bounds of common-sense, and you may have to reject some of your results as not corresponding to reality. The super-abstracted paradoxes of Hegel and the 4th and *n*th dimensions of some mathematicians are merely symbolism divorced from reality, and therefore from truth. Both logicians and mathematicians need the touch of actualities to keep them sane. I think I detect a tendency to hurry towards and exaggerate the symbolic side of Geometry—in the words of my thesis, to sacrifice Presentment to Proof.

2. Another important distinction is in our own nature. There is the *intuitive* power which looks into the essence of things and studies their character ; there is the *ratiocinative* power which loves to prove theorems and to arrange them in order upon an irrefragable basis ; and there is the *ingenuity* which delights in the solving of problems and conundrums. These are not necessarily concurrent in the same pupil. To me the first seems by far the most important ; the usual examination papers test only the second and third. The first corresponds to Presentment ; the second, to Proof ; the third to Puzzle : it is just a logical game, only it gets most marks in the test, and therefore teachers are led to try to inspire the faculty even into pupils who have no taste for conundrums. Again I say, our text-books and examinations seem to neglect Presentment for Proof and Puzzle.

3. A third distinction is also psychological. It seems obvious to say that the function of sense is to provide the raw material for thought, to explore the universe and submit its discoveries to the higher powers. But I notice a tendency in text-books and in the University Syllabus to make the students' drawing exercises retrospective ; they are carefully to measure figures whose properties they have already proved, in order, forsooth, to give them confidence that their reasoning has been correct. Surely this is very topsy-turvy. An army might as well employ its best scouts in consolidating the back trenches.

Bearing these three distinctions in mind, I put forward a few maxims, which I believe are consciously or instinctively followed by all good teachers, but the theory of which seems to require a little urging.

(*a*) *Presentment goes before Proof.*—Presentment means so to put facts before the senses as to make it easy to idealise from them, and so to put inferences before the mind as to make it easy to analyse, classify, and systematise them. We begin well in this matter. We teach our little ones in Kindergarten what they can grasp of the laws of form. But we do not persevere. Just as there ought to be a continuous gradation of object-lessons leading up to some physical science to be afterwards logically studied, so we need a continuous course of drawing and other practical geometrical work to prepare

the mind for the period of proof. Pupils should not be bewildered by a double simultaneous unfamiliarity. Woodwork ought to do much of this for boys; girls are usually without this advantage.

(*b*) *Presentment is often useful without Proof.*—In physical science we do not prove everything: we find it sufficient to train our pupils in the modes of proving, but when an investigation is beyond their reach, we give them results which others have proved. Why not also in Geometry? For example, I always let my class of juniors draw tangents to a circle with the ruler alone, because it is the most accurate way: hereafter they will better appreciate the theory of polars when they come to it. See also a clever specimen of such presentment in Professor Boys' charming little book on Soap Bubbles, where he shows how to get the Conic Sections by the shadows of a candlestick. At Matriculation stage, pupils may well be already drawing ellipses and parabolas in various ways, and even tracing simple forms of third and fourth degree curves.

(*c*) *Proof should follow the Path of Presentment.*—Of course, any valid proof will suffice for logical purposes; but when a teacher offers proof, he is trying to educate as well as prove, and therefore he constantly bears in mind presentments that have been made or are going to be made. For instance, Euclid's I.47 is an ideally perfect proof, because it anticipates the presentment, hereafter to be shown by proportion, that in a right-angled triangle each of the sides is a mean proportional between its projection on the hypotenuse and the hypotenuse itself. Other proofs of this theorem by dissection, etc., are interesting and ingenious, but do not look beyond themselves.

(*d*) *Presentment along with Proof should come as early as possible in the chain of reasoning.*—See the judicious appendix to Euclid's I.32, added by Simson, containing the well-known universal statements about all rectilineal figures. A still better example is Euclid's I.7—a proposition most unaccountably rejected in some modern text-books in favour of a clumsy and uninteresting proof of I.8. The reason of this rejection, they say, is "because I.7 is only used to prove I.8." But surely the meaning of I.7 is to assert the unique property of the triangle, *viz.*, that alone of all rectilineal figures it is unalterable in shape as long as its sides remain the same. The property is, moreover, of immense importance in mechanics. And it becomes possible to present this property as soon as we know what a symmetrical triangle is. The property is true because two symmetrical triangles cannot stand askew on the same base. As soon as we know that property, I.8 needs no further proof.

(*e*) *Appropriate Presentment often makes Proof Axiomatic.*—This we have just seen in the previous paragraph. And this is the best kind of proof, enlightening the intelligence

without obscuring the memory. A good deal of this excellent method may be seen in Henrici's most suggestive little work on Congruent Figures.

(*f*) *Proofs should be Generic and Genetic rather than Ingenious.*—That is to say, if a figure or a property belongs to a family, or may be regarded as having been generated in a special way, proofs should be so chosen as to show forth the relationships of the figure or property, and also, if possible, at the same time to reveal the process of development.

Besides these maxims, I wish to complain that text-book treatment of Geometry is too disjointed. It seems as if some teachers, while rejecting some of Euclid's best excellences, would have us stick to his antiquated form. In Euclid's day, when Formal Logic was a new and fashionable game, nothing could be better than his rigid system of cogent syllogisms. Our minds now-a-days do not love to obtrude the skeleton of their processes, and Euclid's method is now to us tasteless and forbidding. I fear the convenience of having a clear-cut "lesson for to-morrow," or a useful memory-bit for examination purposes, is deciding in favour of an inferior educational form.

All that I have said hitherto I am now going to try to illustrate by a study in the associated circles of the triangle. I may premise that all the proofs I give are my own, with one exception, and even that exception I have so transformed as to give it a new aspect. Not having access to a mathematical library, I have no means of knowing if anything I say is really new. I merely say that this mode of teaching, and these proofs, have not found their way into any text-book I have seen, as it is my belief they should. The diagrams are from my own drawings, not *ex post facto*, but those from which I made the actual study. I put them forward as illustrating Presentment.

Let me begin with the most fundamental of the associated circles, somewhat quaintly called the Nine-points Circle. And let me give the actual way I introduced it to my junior girl-student class, the members of which *hate* Geometry, and cannot endure to have to prove anything—"What's the use," they say, "when we can see it must be so?" I did it in three lessons. The first was a bit of drawing. "Draw a circle, and take any point inside or out. Rule 10 or 12 chords through the point. Bisect all the chord-segments. What is the locus of all those mid-points?" "A circle." "How do you know?" "It looks like it." Then I show them an ellipse that looks very like a circle, and in one case where there is some inaccuracy in the bisections I show a fourth degree curve more like that locus than a circle. Thus they feel the need of proof, and a little judicious guidance brings us to that proof as indicated in the thick lines of Fig. 1.

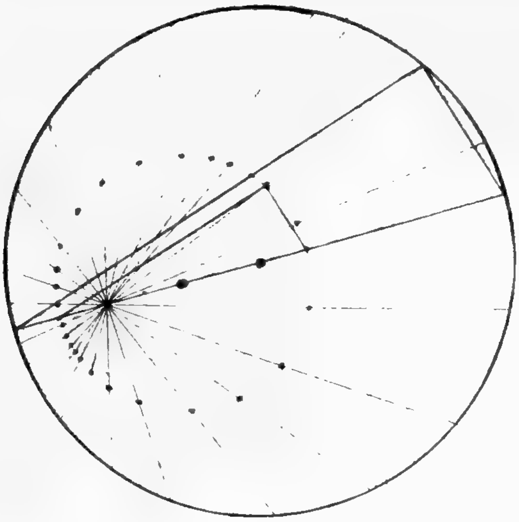

Fig. 1.

Next time, after recapitulation, we clenched the matter by the question, "How many points determine a circle?" "Three." "If, then, from any point O I draw three lines to a circle with centre S, and bisect those three lines, and draw a new circle through those three mid-points, what do you know about that circle?" "It will bisect all the other chord-segments." "And what about the size and position of it?" "Its radius will be half of that of the original circle, and its centre half-way between O and S." "Very well, then ; now we will do a little Kindergarten. Draw a large circle and cut it out. Fold over three arcs of it so as to make a contained triangle, irregular and acute. Prick a pin-hole where two of the folded arcs meet. Fold over the third arc, and see if it passes through the same point." "It does." "Do you recognise the point?" "It looks like the orthocentre." "Prove that it is so by folding the sides on themselves." This done, "Prove it now geometrically by considering the angle BOC and the arc opposite A" (Fig. 2.) They succeeded in this. "Now fold over one of the three arcs again, and trace its outline through O. What kind of a figure have you got?" "A symmetrical figure like a shuttle."

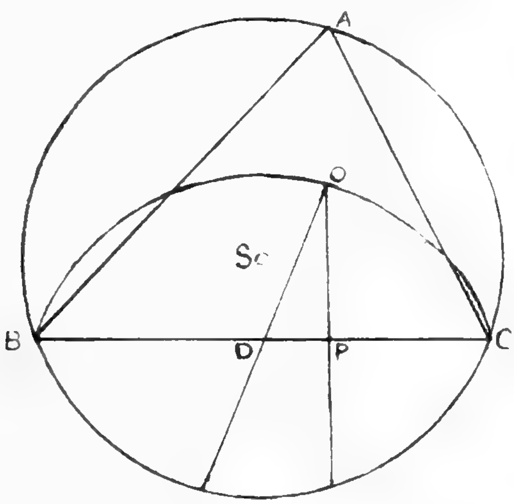

Fig. 2.

"Then what can you tell me about the line OP to the circle?" "It is bisected at P." "Why?" "Perpendicular to the axis." "And what about OD?" "Bisected at D." "Why?" "It's the centre." "As it is the same for the other sides, what can you tell me now about PQR and DEF?" "A circle will pass through all of them." "And what else will it do?" "Bisect all the chord-segments from O." "Especially——?" "OA, OB, OC." "Well, then, you have proved the Nine-points Circle. And its size and position?" "Radius half the circum-radius, and centre the mid-point of OS."

Now the proof given in Mackay's Euclid is based on the following figure (Fig. 3), and everybody can see how uncharacteristic and repellent it is. And even so, a separate proof depending on a different principle is required for the size and position of the circle.

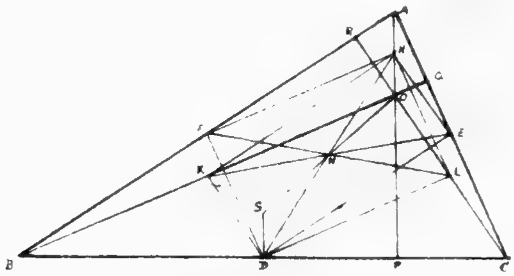

Fig. 3.

This is as if we set out to prove the rationality of man, and started by showing historically that man is "a biped which cooks its food," and so bring it in as a corollary, "hence it should seem that man has some claims to be called rational."

Our third lesson on the subject was pure Kindergarten. The final result of it is indicated in Fig. 4; but I would advise the young teacher to do it with me step by step. "Cut out a large triangle—scalene and acute, because we want the perpendiculars inside. Pinch the mid-points of the sides. Fold over the joins of the mid-points, and open the triangle again. Now mark ABC and DEF as usual. On the reverse side of the angles ABC mark them PQR. Now fold over A as before: will P fall on BC?" "Yes: the triangles are equal, halves of a parallelogram." "Will P be on the same circle as DEF?" "Yes: the angle P or A is the same as D, opposite in the parallelogram." "Then PQR and DEF are on the same circle?" "Yes." "But what are the points PQR?" "Feet of the perpendiculars." "Fold so as to show this. How do you know it?" "Because when you fold over a triangle you make a symmetrical figure—a kite; and its diagonals are at right angles." "Then the last three folds were concurrent in the point——?" "O." "So it's our old friend again. Now pinch the mid-points of OA, OB, OC—call them UVW. What can you see about the triangle UVW?" "Its sides are parallel to those of

ABC." "And size?" "Half of ABC?" "Half?" "Well, the dimensions are half." "Now look at O in that triangle: what is it?" "Why, it's the orthocentre of that, too." "And are OP, OQ, OR bisected?" "Of course." "Then what do you know of PQR from our last Kindergarten lesson?" "They are on the circum-circle of UVW." "So we have the Nine-points Circle again." "But if it does all that, why do they call it the Nine-points?" That, I told them, is precisely what I am asking the mathematicians.

This dialogue, though of course compressed, is not exaggerated; and perhaps it will illustrate my thesis if I say that these girls, who give such intelligent answers and make such a shrewd comment at the end, are quite likely to fail in mathematics at the next Matriculation, because Proof bewilders them and Puzzles annoy them. My contention is that such correct intuition as they constantly show ought not to be ignored in any educational scheme or test.

The proof I have just given may be shown, perhaps more to the satisfaction of a mathematician, by invoking another principle. When we draw or imagine a figure on a plane, we see only one side of that plane. But there is another side to it, and Nature never forgets this. She persists in looking at the "wrong side of the pattern" as well as the right. Or, to personify even more, Nature likes to look at herself in a mirror, where the right hand becomes the left. Hence in Geometry the mirror is a very useful instrument of Presentment. It reveals symmetry where it has been retained, and restores it where it has been lost. I find, moreover, in teaching, that a mirror with a class of girls has a singularly effective power of riveting the attention, though they always indignantly deny that it is so. In doing the last exercise with a mirror, one wants to see through the mirror as well, and in this case it is better to use a bit of plain glass and get one's pupils to look through it at the angle of total reflection, when the whole symmetry will be admirably shown. For drawing purposes I shamelessly use tracing paper. Let not the trained mathematician scoff: a teacher must gather geometric gear by every wile that's justified by honour. If I may say so, I do not visualise easily myself, and this despised trick has helped me considerably. So we draw a triangle, calling it (prophetically) DEF; trace it on the transparent paper; now turn the triangle round, first on EF, then on FD, then on DE, and mark the new vertices PQR. (Fig. 4.) Rule the new sides, and complete the larger triangle ABC. We have now a fresh proof of the Nine-points Circle, which I need not elaborate.

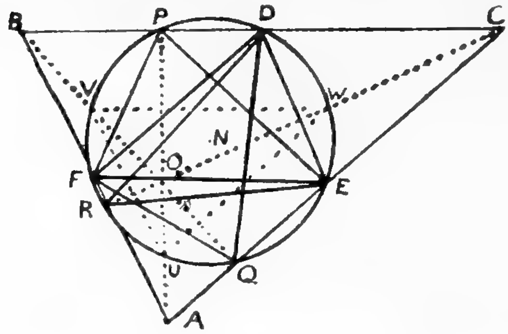

Fig. 4

These proofs have been genetic rather than generic; that is, they show how the circle may be supposed to have been generated, but they do not place it in relation to the other circles of the triangle. Yet even here we see a family of circles. The orthocentre is perhaps the most fundamental point of the whole triangle, and if the lines OA, OB, OC are divided in various proportions and the points of division joined, we have an infinite series of triangles with their circum-circles, such that O is the centre of homology and of similitude and the orthocentre of the whole group, and all the centres lie on OS. If J be the moving point, when the ratio OJ : JS is 0, we have the starting point; when it is 1, the Nine-points Circle; when 2, the circle whose centre is G; when ∞, the circum-circle. The family, however, is not very important to the triangle, since the only other obvious common property seems to be that they cut OA, OB, OC antiparallel to the opposite sides. Still, there is the family, an infinite series of circles alternately Nine-points and Circum-circles to one another.

The last proof was got by reversing the triangle on its sides; a far more fruitful process is to reverse it on its angles. (See Figures 5 and 6.) The chief result of this is that all transversals and all lines through the angles become antiparallel to their former selves, and antiparallelism is a prolific source of symmetry. After a diligent course of drilling with the aid of tracing paper, even the most backward pupils get a clear notion of the properties of antiparallels, *e.g.*:—

(1) Every transversal with its antiparallel and the sides makes a cyclic quadrilateral;

(2) Every parallel to *a* makes with its antiparallel the angle B $\sim$ C, etc.;

(3) All antiparallels to the other two sides make the angle A with *a*, B with *b*, C with *c*: therefore on each side of the triangle there fall two sets of antiparalleis, making isosceles triangles on it.

The drilling in this matter is so important that I add a special exercise. Draw any angle BAC, and suppose a point

P to move along any line AD through A. Drop the perpendiculars PX, PY, and join XY. Do this from more than one position of P.

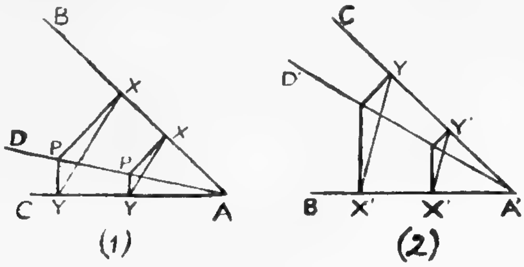

Fig. 5.

Now turn the whole figure round and it takes the form (2) in Fig. 5. Then if (with tracing paper, and afterwards mentally) the figure (2) be imposed upon (1), it becomes axiomatically evident (*a*) that A^1D^1 is antiparallel to AD; (*b*) that the proportion of the perpendiculars (which determines the interior angle) is reversed; and (*c*) that Y^1X^1 is antiparallel to XY. These results will be useful in a future proof.

The method goes further still and brings out a most vital property of the triangle. Consider the following figure (Fig. 6):—

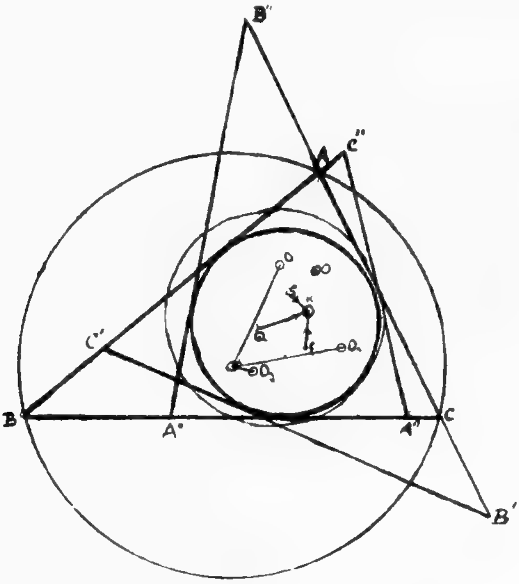

Fig. 6.

Here we have the triangle ABC turned on its angles so as to form three symmetrical arrow-heads. We see at once that the one thing remaining constant is the in-circle with centre I (the Nine-points and Circum-circle have been unnecessarily drawn). Any other point besides I takes up three new positions on the lie of its antiparallels. I have marked those of O

and G. Now by drawing (we shall prove it presently) we see that AO_1, BO_2, CO_3 are concurrent, meeting in S; S therefore in a special way corresponds to O—it is a sort of *average* of the three moves of O. So also G has its corresponding point K. In these two cases S and K, by virtue of the properties of O and G, acquire a whole set of new symmetries. S of course (I do not pause to prove it) is the Circum-centre, and K (quite undeservedly neglected in elementary text-books) may be called the Anti-centroid. It has been called the symmedian, as being the point of concurrence of the symmedians; but it seems to me more convenient to reserve that adjective for the *lines;* otherwise why not call the centroid the median?

These are the two principal pairs; but it is evident that every point in the plane is given by this triangle its corresponding point—its affinity, so to speak. In other words, each triangle polarises the whole plane in its own way point by point, just as each circle polarises it circle by circle, though of course the polarising differs in the two cases. This is a most fundamental property. Mr. Johnson, in an admirable chapter on the Geometry of the Triangle in his Trigonometry, calls all such pairs of points Anti-centres. I do not like this use of the word *centre* for points which have nothing really central about them; I suggest the term Twin-points. Obviously the in-centre is the one point in the plane which is its own twin; it must be regarded as a double point. It will be found that every point on each of the sides corresponds to the opposite vertex; consequently we have to strain the meaning of *twin* in the three cases A, B, C: the family becomes rather large. But it is quite as much a strain to say that the whole side BC produced to infinity is the anti-centre of A.

Now this expansion of the triangle through the whole plane, with its scheme of antiparallels and the resulting twin-points, opens up a wide range of geometrical ideas.

Let us first take antiparallels by themselves. They will provide us with both a new proof and a new view of the Nine-points Circle, which from now I am going to call, from its development, and from its centre being the mid-point of OS, the Ortho-centric Twin-point circle. One day, after my class had bisected the sides of a triangle and drawn the consequent triangle of parallels, I told them to draw a transversal anti-parallel to each side. As they had no tracing-paper handy, they hesitated. Thereupon, foreseeing what they would do, I reminded them of the cyclic property. At once they drew a semicircle on each side. Then followed a surprised exclamation: "Why, it forms another triangle!" "Just so," I said; "now what triangle is it?" They soon recognised it as the orthocentric. (Fig. 7.) "So, then, looking for antiparallels, you find O again. Now, by the way, what's O to that triangle?"

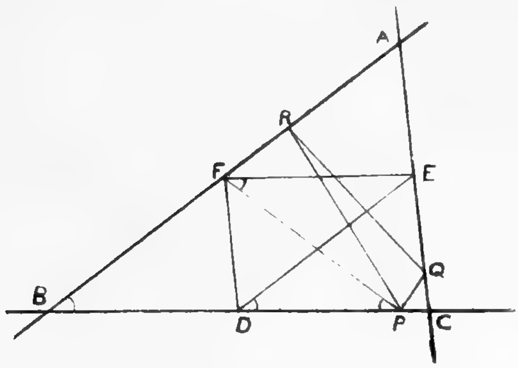

Fig. 7.

"It looks like the in-centre of it." "Can we prove it?" "Yes (after thought), because the antiparallels make the angle A with a so that OP bisects RPQ, and so with the others." "Very well; now can we prove that DEF and PQR are on the same circle?" Here I had to help them out. By antiparallels, DPQE is cyclic, so is QERF; here, then, are two circles with two points in common: if they have a third, they are identical. But by equality of the angles marked (FP=FB, being radii), F is concyclic with DPE; hence we have once more the Orthocentric Twin-point circle substantially proved (the other three points being easily brought in), and we recognise it as the bringer together of parallels and antiparallels into one bond of symmetry.

Now we have seen that S and K correspond to O and G; AO, BO, CO are perpendicular to the parallels, therefore AS, BS, CS are perpendicular to the antiparallels. AG, BG, CG bisect the parallels; therefore AK, BK, CK bisect the antiparallels. Then, since pairs of antiparallels to two sides make equal angles with the third side, their perpendiculars will do so also; hence SA and SB, being perpendicular to lines making the angle C with c, form a symmetrical triangle with the angle $90°$—C. at the base; SB and SC behave similarly; hence SA, SB, SC are equal, and we have the Circum-circle from a new point of view.

Again, owing to this property, through every point within the triangle there pass three antiparallels, making symmetrical triangles on the sides (I refer again to the tracing-paper drill). But as K is a point, and the only point, where all these three antiparallels are bisected, we see that K is a point, and the only point, from which as centre a circle can be drawn cutting the sides of the triangle at the ends of three diameters. Now, as these diameters are antiparallels to the sides, it follows (from the cyclic property) that the other chords across the triangle are parallel to the sides. This, then, is a simple proof of what is called the Cosine circle—I should prefer to call it the Anti-

centroid circle; the other name is derived from a subordinate property.

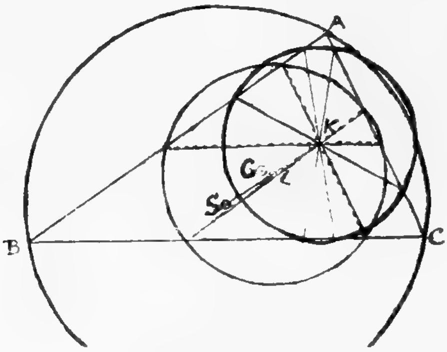

Fig. 8.

The Anti-centroid circle, as we shall see presently, is the minimum member of an interesting group of circles, each cutting the triangle so as to have three transverse chords parallel to the sides, and three antiparallel to them. Let us now introduce a new member of the family. Through K draw three parallels to the sides; these, of course, form three parallelograms with the sides (Fig. 8); and KA, KB, KC bisect the other diagonals. But the transversals which KA, KB, KC bisect are the antiparallels; and parallels with antiparallels form cyclic quadrilaterals; thus the six ends of the parallels through K are four and four concyclic in three sets. The centres of these circles are where the symmetrical bisectors of the antiparallel chords meet. But these bisectors are parallel to SA, SB, SC (which are respectively perpendicular to the antiparallels), and as they start from the midpoints of KA, KB, KC, they must be concurrent at the midpoint of SK. The three circles, therefore, are the same, and this is a simple proof of what is called the Lemoine circle.

It is easily seen, as Johnson points out—and it can be proved by quite similar reasoning—that if KA, KB, KC are divided in any other ratio, a set of circles all centred on SK cut the sides of the triangle with parallel and antiparallel transversals. If again J be the moving paint, then, when the ratio KJ : JA is 0, we have the minimum, the anti-centroid circle; when 1, the Lemoine; when ∞, the Circum-circle, because there the parallels merge into the sides and the antiparallels vanish into the vertices (*i.e.*, the tangents to the Circum-circle at the vertices are antiparallel to the sides). The whole family is called the Tucker circles; I do not see why we should not call them the K-circles, and the Lemoine the mid-K-circle. The other names seem to give Messrs. Lemoine and Tucker something too much of precedence in Geometry.

It will be observed that here again the Circum-circle occurs not as a primary, but as a derived adjunct to the triangle,

though in our rudimentary studies we first came upon it as the result of the confluence of three easy loci.

About this series of K-circles Mr. Johnson makes the curious remark that it is unique in having its transverse chords parallel to the sides; but surely he has forgotten the Orthocentric Twin-point circle, which does not have its centre on SK, but which has this property, and which, indeed, seems to insist on belonging to every family of circles the triangle possesses.

And now for the last family. As it is not yet named, I am going to call it the Twin-point family. It depends on the fundamental property of Twin-points. Mr. Johnson puts this property quite at the end of his chapter as an appendix. Its presentment should come earlier. The property is that if from each of a pair of twin-points we draw perpendiculars to the sides of the triangle, the six feet of the perpendiculars are concyclic on a circle whose centre is the mid-point of the join of the twin-points. Let us prove this at once. (Fig. 9.)

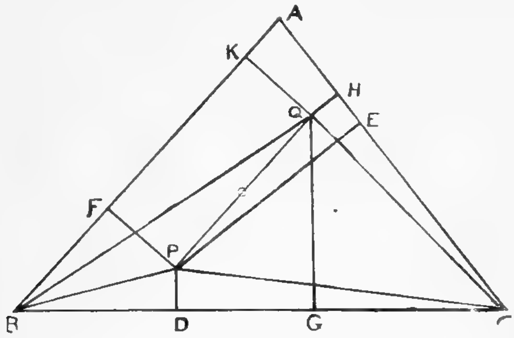

Fig. 9.

When we were reversing the triangle by means of tracing-paper, it became obvious that any line through a vertex with its series of perpendiculars on the sides and of bases joining the feet of the perpendiculars would (1) become antiparallel to its former self, (2) reverse the proportion of the perpendiculars, and (3) make the bases antiparallel to what they were. In this figure (9) let any point P be taken and BQ, CQ be drawn antiparallel to BP, CP; we must now first show that AQ will also be antiparallel to AP. It is obvious that QH and QG reverse the proportion of PE and PD; similarly, QK and QG reverse the proportion of PF and PD; combining these proportions, we see that QH and QK reverse the proportions of PE and PF—*i.e.*, Q is on the antiparallel to AP; therefore, if P be any point, the antiparallels of PA, PB, PC through the vertices are concurrent. Then, since the bases HG, etc., are antiparallel to their former selves (DE, etc.), DGEH is cyclic; so is EHKF. The centres of these two circles are where the symmetrical bisectors of DG, EH, KF meet; but these, running midway between the perpendiculars, are obviously concurrent at the mid-point of PQ. Hence the six feet of the perpendiculars of twin-points are concyclic; and the centre of the circle lies midway between the two points.

Simple and obvious as this proof is, I cannot help thinking it is new; for if it were known, Mr. Johnson would surely not have been content with the complex, though ingenious, proof he actually gives—a proof depending on the property that (T being the mid-point of PQ), $TD^2 = TP^2 + PD, QG$.

This property can hardly be called fundamental. I did not know it myself, and had to prove it before I could proceed, and I should certainly not expect my pupils to remember it.*

Let me also remark here how the same proof does for both the K-circles and the Twin-point. If you want to kill birds, it is surely good economy to kill two birds with one stone—best of all if you can bring down two whole flocks with one shot.

Here, of course, is a fresh proof of the Orthocentric Twin-point circle. O and S are twins, therefore DEF, PQR are concyclic, and the centre of the circle bisects OS; and if U be the mid-point of OA, U is on the same circle, either because it is the centre of the circle OQAR, and therefore QUR $= 2A =$ supplement of QPR; or because FU and EU are parallel to BO and CO, and therefore contain the supplement of A, so that FUE and FDE are supplementary. In fact, there seems to be no limit to the proofs of this wonderful circle.

The In-circle is, of course, a special case of this family. The twin-points coinciding, the six feet of the perpendiculars coincide two and two, and the circle touches the sides. It is the minimum of the family.

Perhaps the chief interest of this family lies in the tangency between the Orthocentric and the In-circle (there is no time to discuss the *e*-circles). A very good way to see the relation between the two is to draw tangents to the Orthocentric parallel to the sides, turning the circle into an In-circle. (Fig. 10.) The joins of corresponding vertices, as the drawing shows, meet where the circles touch. The point H, then, the centre of homology and similitude, may be regarded as generating the whole figure, and we have an infinite series of circles alternately In-circle and Orthocentric to one another.

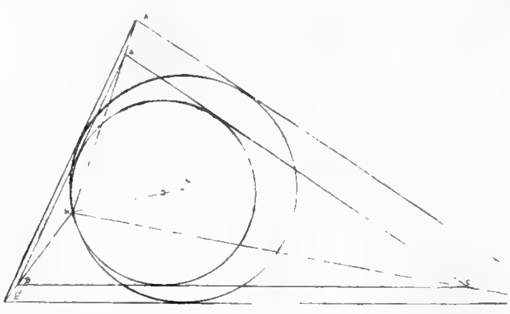

Fig. 10.

* If I criticise Mr. Johnson, it is *honoris causa*; I wish to give my argument an *a fortiori* value. His treatment of this topic is the best I know, and I desire to say emphatically that I owe it to himself that I am able to criticise him at all.

But this tangency is by no means unique in the Twin-point family. Indeed, at first I thought it was the usual thing. Several times, drawing at random, I found other Twin-point circles behaving just like the Orthocentric towards the In-circle —*e.g.*, in Fig. 11.

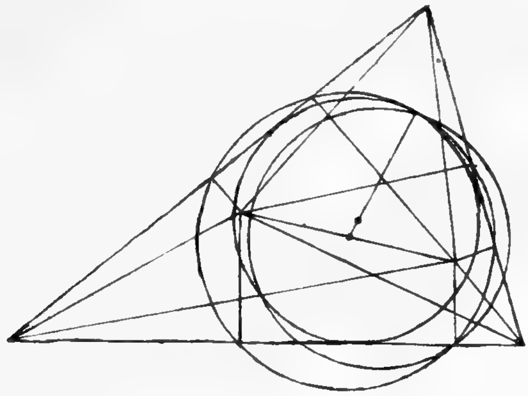

Fig. 11.

However, on carefully choosing points in all portions of the triangle, I got a very interesting result (Fig. 12). Obviously there is a complex locus of points whose Twin-circles must touch the In-circle. One circle cannot pass continuously into or out of another without touching it. The locus must have double points at the vertices and at I, and apparently passes twice through each side. This becomes evident while we draw the successive circles and imagine those that intervene. To get the full value of this presentment, the student must have the industry to do it for himself.

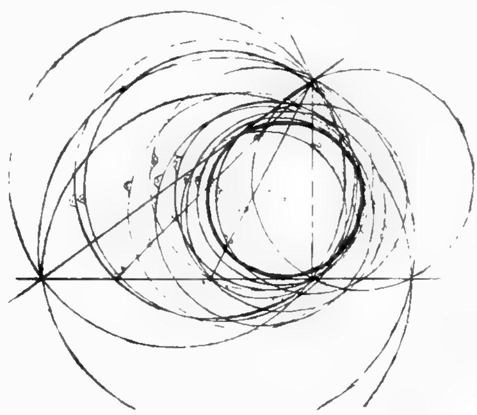

Fig. 12.

Algebraic calculation gives me an equation of the 8th degree for the locus; but its form is not inviting, and I learn more from the Presentment than from this symbolic Proof.

I will just add my transformation of the proof of the tangency of the Nine-points with the Inscribed circle, as given in Johnson's Trigonometry. The only quantitative relation between the two circles given by elementary geometry is that

DX is the mean proportional between DL and DP; this, therefore, is the property we necessarily use. Now, when the triangle is reversed along AL (the angle-bisector), the tangent LX becomes LX^1, and being now antiparallel, is, of course, at an angle C-B to its former self. Now take the three points X^1, L and P (characteristic points respectively on the In-circle, the triangle and the orthocentric twin-point circle), and describe a circle through them, cutting the In-circle again at H.

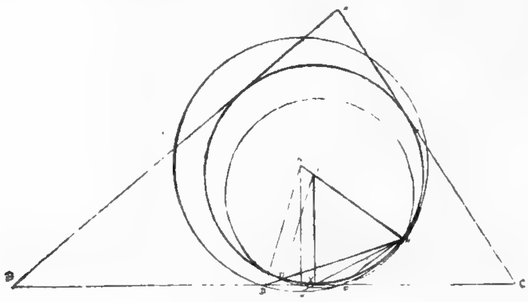

Fig. 13.

Now HX^1 will meet BC at its mid-point; for DX^1, DH = DX^2 (for one circle), and = DL. DP (for the other). Therefore DX is the mean proportional between DL and DP, and consequently D is the mid-point of BC. Again, the angle DHP being in a cyclic quadrilateral = the angle DLX^1, *i.e.*, = C-B. But C-B is the angle which DP subtends in the orthocentric twin-point circle (a well-known property, easily proved). Therefore H is on both circles. And because XIX^1 at the centre = C-B, the angle DHP at the circumference is bisected by HX, and therefore HX bisects the arc DP. Hence the joins of the ends of two sets of parallel radii meet in H, which is therefore the centre of similitude, which, being on the circles, must be a point of tangency.

Here, again, we see how the triangle subdues the whole plane to itself. There are three of these auxiliary triangles and circles, one for each side of ABC. H, being a centre of homology, may therefore be regarded as a point generating four infinite series of circles, each series being in contact at the starting-point. And as the same holds for the *e*-circles, we have sixteen such series sweeping fan-shaped through the plane. It is a kind of geometrical picture or analogy of the way in which each individual mind polarises the whole universe to its own personality.

COMET 1916a.—On the 24th February an apparently short-period comet was discovered at the Simeis Observatory, Crimea, by M. Neujmin. It was then 6° south-west of Mars and of the eleventh magnitude.

SOUTH AFRICAN MUSEUM.—The Director of this Museum, in his report for the year 1915, states that he has instituted an osteological gallery in a building erected as a store room two years ago. In this gallery 247 skeletons and skulls have recently been placed, ranging from the largest mammals to bats and frogs. A collection of 150 human crania has been arranged on specially-made stands. The Director deplores the fact that five large skeletons of whales, hitherto exhibited in the open, are fast decaying. A 19 feet long specimen of *Orca gladiator* has recently been added to this collection. One fin whale from the South African seas is as yet unrepresented, and a skeleton of the sperm whale is still at Cape Point awaiting transfer to the Museum grounds. Of insects, 3,752 different species were received during the year, 1,015 being new to the collection, and a large number of species remain unidentified. In the mineral collection the work of rearrangement of the crystals, determination of faces, and labelling, carried out by Prof. Shand, is nearing completion, and constitutes a new feature in South African Museum work, and will be found most advantageous for students of minerals. An assortment of minerals, rocks, and fossils from Australia forms an important addition to the geological, mineralogical, and palæontological department, and includes a collection of Australian radio-active minerals. The Karroo fossils have been arranged in stratigraphical order, and the fine skeleton of *Pareiasuchus* is now effectively displayed. A cast of *Rhinesuchus senekalensis* and a complete skeleton of *Struthiocephalus whaitsi* are amongst the more important additions.

SOIL SCIENCE.—A new monthly journal is about to be published in the United States of America, under the name of *Soil Science*. It will be international in scope, confining itself to problems in soil physics, soil chemistry, and soil biology. The editor in chief will be Dr. J. G. Lipman, of the New Jersey Agricultural Experiment Station, and there will be associated with him a consulting international board of soil investigators. Twelve of these will be amongst the leading authorities on soils in the United States and eleven representatives of other countries.

THE ROYAL SOCIETY.—Amongst the names recommended by the Council of the Royal Society (London) for election as Fellows are Dr. G. G. Henderson, Professor of Chemistry in the Glasgow and West of Scotland Technical College, who was Recorder of Section B of the British Association during its visit to South Africa in 1905; Mr. John E. Littlewood, a son of the Principal of the Boys' High School, Wynberg; Dr. H. H. W. Pearson, Professor of Botany at the South African College; and Mr. J. H. Maiden, Government Botanist at Sydney, N.S.W., who was for many years a generous contributor of specimens of Australian flora to the Cape Government Herbarium.

GEOGRAPHY.

By James Hutcheon, M.A., F.R.S.G.S.

What is Geography? The question is one which has been engaging the attention of geographers for many years, and even to-day there is considerable uncertainty as to what is the exact scope of the science. In South Africa, of late, few subjects have been more frequently discussed in educational circles, and, as this Society is a patron of science, it seems meet that a few minutes should be spent in an endeavour to discover the true sphere and to discuss the prospects of a subject which is of so great importance to men, both individually and collectively.

In order to understand more clearly the present significance of the term, it may be helpful to glance at the development of the subject from early times. To the inhabitants of the Nile and Euphrates Valleys it meant what we now regard as surveying, and they first used it in the apportioning of their fertile lands, and, later, in dealing with such problems as the size and shape of the earth. According to several authorities of to-day, this is the only phase of the subject which is worthy of any serious consideration. In the sixth century B.C. the first map of the world was compiled, and about a century later Herodotus wrote his first treatise on descriptive geography. As new regions came under the sway of the Southern Empires, descriptive geographical literature increased. It was at a much later date, however, that the scientific treatment of the subject began, when, from being a mere collection of unrelated facts, names, and figures, geography became a synthetic science, investigating the control of man's activities by the interaction of numerous causes and effects known in geographical terminology as the *milieu*.

As in other sciences, there are three stages, namely, the collecting, the classifying, and the explanatory. It is not one of the fundamental sciences, since it builds, as it were, with the bricks supplied by the geologist, meteorologist, anthropologist, etc., and in this respect it is not unlike sociology.

But it is altogether erroneous to imagine that it is composed of a chaotic medley of "snippets" from other sciences. Doubless, in several cases, the phenomena under investigation are the same, but the points of view are totally different, for Geography is interested in the various distributions only in so far as they have human significance. It is a mistaken conception of the relation of Geography to the tributary sciences that has given rise to the encyclopædic connotation of the term, which is so frequently brought forward as an objection towards its inclusion as a subject for study in higher educational institutions.

There are, indeed, several schools of Geography, but only

two receive any degree of recognition—the physical, and the human. To the latter, which regards the scope of geography to be the study of the influence of environment on the life of man, and his reaction on that environment, belong more than a half of the world's geographers.

There is an idea abroad that the geographer is an authority upon most subjects, and is fairly conversant with all. Designate astronomy "astronomical geography," call surveying "practical geography," and he is frequently expected to be able to solve the numerous problems which confront experts in these branches of knowledge.

It is only natural to expect that teachers of geography who have approached the subject through the avenues of other sciences will be biassed in their treatment of it. If geologists, then physical geography will attract them; if economists, commercial geography; but, although a general training in geology, meteorology, anthropology, etc., is essential to the understanding of many problems in geography proper, it is as unreasonable to expect the student of geography to possess a thorough knowledge of these sciences as it is to imagine that the doctor who employs the results of geographical inquiry in order to find suitable climates for his invalids, is a trained geographer.

Some consider as essential a knowledge of surveying, which they name "practical geography"; but if the word "practical" is intended to convey a meaning similar to that in the case of "practical botany" it is a misnomer. Obviously, it is not possible for the geographer to bring his material into the laboratory; in most cases it is not convenient for him to make personal observations in all parts of the globe, hence there arises the necessity for a notation; but all that can be said in favour of the absolute necessity of an intimate knowledge of the making of maps is, that in the case of a geographer exploring unaccompanied by a surveyor, it is indispensable. In these days, however, wherever work of real importance is being carried on, such circumstances are practically non-existent. The relation of surveying to geography is much the same as a knowledge of printing scores is to the interpretation of music. It would appear, then, that the term "practical geography" should be applied only in the case of actual investigation "in the field." The world is the laboratory, and man, in his environment, the material.

The geologist concerns himself with the past history of land forms, while the geographer deals with their present state of development, treats them as the home of plant, animal, and man, and notes the influence of configuration, minerals, etc., on the distribution of population, industries, commerce, and trade routes.

The geographer need not trespass on the realms of the physicist or the meteorologist in order to explain exhaustively the various factors determining climate. The question he must

answer is, "How do certain given climatic conditions affect the life of man?" Of all the external modifying forces which influence mankind, there is little doubt but that climate is, in the main, responsible for the different stages of his physical, mental, and moral development. The almost innumerable gradations from stunted Pigmy to stalwart Dane, from loin-cloths to furs, from bread-fruit to blubber, from palm-hut to igloo, from lethargy to energy, and from infanticide to high morality, are in no small degree determined, directly or indirectly, by atmospheric conditions. Climate controls the vegetable and animal products which form the basis of man's food, and change of latitude or elevation necessitates a variation of diet. The luscious fruits of the tropics would make an ill substitute for the wholly animal fare of the Arctic regions. Perhaps the most obvious examples of adaptation to climatic environment are found in a survey of the world's modes of dress. The flimsy tropical cotton makes as striking a contrast to the thick polar furs as do the dull clothes of the grey North to the gay garb of the sunny South. Architecture also reflects climate, for dwellings are to a great extent built at the dictates of temperature and rainfall. Flat roofs are an indication of rapid evaporation of rainfall, the steep roofs of snowy countries are self explanatory, while pile or tree dwellings are characteristic of lands subject to floods. Nomadic peoples in search of pasture or water inhabit temporary, movable structures, but in settled agricultural or industrial regions are found large, substantial edifices. The ornamentation of the latter, also, is regulated by the weathering agents. Climate influences even religious beliefs, for the hell of the Eskimos is a region of darkness and intense cold, while that of the Jew is a place of eternal fire. We have quoted only a few instances, but the study of the influence of climate on sports, customs, social conditions, literature, place-names, intellectual pursuits, and temperament is one of the most fascinating branches of geography. Investigation proves that there is scarcely any phase of human activity but bears the stamp of climatic environment.

The distribution of plants and animals are of interest to the geographer only to the extent that they have a bearing on the life of man.

A knowledge of geography is of much greater value to the historian than a historical training is to the geographer, for geography is the stage on which the tragedies and comedies of history are enacted.

Similarly, economics enters into the arena of the geographer only in so far as industries, power, labour supply, markets, etc., are determined by the geographical *milieu*.

The foregoing sketch will help to show that, although there may easily exist many differences of opinion regarding points of minor importance, the province of the geographer is fairly clearly defined, namely, the study of man's "passive" and

"active" relation to his natural environment. It is well to note here that there is frequently a tendency on the part of the geographer to attribute too much to environmental control: in his devotion to "determinism" he is apt to neglect "free-will." Besides, owing to universal evolution and to man's own "conquest of nature," environment is constantly varying. Man, likewise, is changing, and hence the conclusions of the geographer must necessarily be of a temporary nature—they apply only to one particular time. As regards the future, they can only suggest possible developments. Let us attempt to indicate briefly the future work of the geographer, making special reference to South Africa.

As *terra incognita* is now almost unknown, the work of the exploring, or "practical geographer," as he may be called, becomes every year more limited, but there is still need for him in South America, and in isolated regions elsewhere. Meanwhile, however, the eyes of the world are fixed on the vast continent of the south, Antarctica. Perhaps the next great expedition will throw light on the bewitching problems of palæo-geography; perhaps this lone-land will prove a store-house of mineral wealth; perhaps it will provide the Australian meteorologist with the key to the understanding of his climatic conditions.

In cartography, maps showing every type of geographical distribution should be available. The great international map will make possible the universal use of certain symbols and modes of spelling. There is scope for cartographical representation of the distribution of soils, and of the actual and potential productivity of agricultural districts. Hydrographical surveys should be easily available, especially in countries where water is wealth. Maps showing the present and past distributions of forests and rainfall, and of drained land and malaria, will probably receive more serious consideration; even statistics may possess some charm if presented in map form.

The geologist may help by indicating the presence of valuable or useful minerals, and may lead through the avenues of paleontology to the worlds of the past.

Recent marine catastrophes, even in the most familiar highways of the sea, have revealed the fact that on every hand lurk sources of danger which demand the further attention of the oceanographer.

Although the meteorologist cannot alter the courses of cyclones, he may be able to suggest new means of modifying, to some extent, the results arising from local climatic conditions, in order to make possible the more complete Europeanisation of tropical lands with their almost unlimited productive potentialities. Here the burning question seems to be, "Is South Africa drying up?" The preparation, distribution, and intelligent interpretation of meteorological charts are absolutely essential for safe navigation, profitable fishing, and thoroughly suc-

cessful farming. The bearing of meteorology on aviation is of premier importance, and before long aerial conveyance is likely to demand very serious consideration from the geographers of commerce.

Botanists, zoologists, anthropologists, etc , after more comprehensive observation and exhaustive investigation, in which innumerable indirect causes will not fail to receive due consideration, may discover laws regarding man's distribution and racial characteristics which will stand the test of universal application.

Questions regarding a topographical nomenclature for general adoption, the distribution of tropical diseases, the world's decreasing coal supply, the latent power of oil, water, tides, and the sun and the alteration of the great trade routes, giving rise to such local questions as shipping accommodation, storage, etc., must all receive attention from the geographer of to-morrow.

The establishment of an Imperial Geographical Information Bureau, which would collect and distribute information regarding all matters geographical, would prove a tremendous boon. In such an institution could be kept series of maps, samples of products, lantern slides, geographical literature, etc.

In South Africa the day of geography is just dawning. During the past twelve months no fewer than three syllabuses for advanced examinations in geography have been arranged, and various courses of training have been established by the Provincial and Union Education Departments for teachers desirous of obtaining special qualifications in the subject.

To many who left school in the years gone by, even after completing a "secondary" course, their own country was little more than a "Dark Continent." Now, from the points of view of cultural, disciplinary, imaginative or utilitarian education, few countries in their geographical study offer greater attractions than Africa. The fascinating story of its discovery, the apparent relation between its economic development and its geological structure, the numerous illustrations in recent times of the importance of military geography, its extensive range of climatic conditions and their influence on man and his work, the varied nature of its bio-geography, its cosmopolitan population, its dependence on other countries, together with the fact that it can boast of no mean portion of the world's grandest topographical features—all would seem to advocate a more comprehensive study of the subject than has hitherto existed.

In the past, geographical enthusiasts have been faced by many difficulties, but these are gradually being overcome. Detailed contour maps of several districts are now available, books written from the South African point of view are on the market, and as "home geography" is so prominent a feature in all the afore-mentioned syllabuses, several gentlemen, who are forming themselves into the nucleus of a Geographical Society, are considering the advisability of instituting what may be termed a

"Geographical Census," in order to obtain from every possible source information with a view to the preparation of geographical monographs. The following is a *résumé* of the proposed scheme of local investigation:—

Indicate on the enclosed map the area to be dealt with. (N.B.—In dealing with the various distributions—geological, climatic, plant, etc.—supreme importance is at all times to be attached to their bearing on the life of man.) Where possible, indicate distributions on maps. Give a general description of the region, noting configuration, exposure, drainage, forest, bush, pasture, cultivated land, and desert. State directions, approximate distances, areas, heights. Remarks regarding the relation of scenery to geological formation, nature of soil. Notes on topographical features of special interest—*e.g.*, results of denudation, periodicity of rivers, alteration of water-courses, hot springs, caves, vleis, etc. Supplementary remarks regarding local methods of preventing erosion.

Climate.—Average summer temperature; average winter temperature; variation of temperature (day and night,, summer and winter); prevailing winds (their origin, characteristics and seasons); average rainfall (characteristics). Further remarks regarding climatic phenomena. Information concerning local causes of above; effects of storms on crops; "wash-aways"; means employed for encouraging rainfall, etc.

Production.—General description of natural vegetation. Note any local causes of outstanding importance that have led to the present distributions. Economic importance of vegetation; methods employed for the destruction of unprofitable plants.

Land under Cultivation.—Trees—(1) firewood; (2) timber, useful or ornamental; (3) fruit; (4) for any other purpose. Cereals—other vegetable products of economic importance. Note any local conditions specially suited for the production of above, and name other plants which you consider may be successfully cultivated. Note any special adaptation of vegetation to local conditions. Give particulars regarding any reaction of vegetation on climate or water supply, etc., diseases or pests hindering cultivation, methods of agriculture peculiar to the district and necessitated by the geographical environment.

Animals.—Wild animals, birds, fish of the district which are of economic importance. Domestic animals—their value to man, their food and methods of storing it. Note how local conditions have affected the rearing of certain animals. Note any relation between animals and the distribution of diseases affecting man.

Minerals.—Local distribution (indicate on maps). Note the relation to geological structure. Useful minerals, annual output; valuable minerals, annual output; local uses of minerals.

Industries.—Chief local industries. Remarks regarding—(1) labour supply; (2) distribution of industries among inhabit-

ants of different nationality; (3) sources of power; (4) local conditions specially favourable or unfavourable to the development of present or future industries. Industrial products.

Exports.—Chief exports and their markets (home and foreign). Conditions affecting markets, and amount of export.

Imports.—Chief imports; their sources, conditions regulating importation, and means of distribution in the locality.

Means of Trasport.—How controlled by local conditions.

Chief Trade Routes.—How fixed by local conditions. Remarks regarding any proposed routes; their probable effect on local industries, distribution of population, etc. Notes on points of strategic importance.

Means of Communication.—Note anything of special local importance.

Centres of Population.—Note local conditions which have led to rise of towns, villages, and settlements. Distribution of races and nationalities; causes leading to same. *Notes on the following*:—Influence of local geographical conditions on the physique of the inhabitants; habits; customs; sports; punishments; character and beliefs; dress; houses; place-names; literature. Give particulars regarding birth and death rate, diseases prevailing in the locality, and of the type of invalid, if any, for which the locality is specially suitable. Indicate any relation between above and local geographical conditions.

Any supplementary information, with quotations or references to authoritative local papers, magazines, or other works. Where possible, paper cuttings containing relevant information, photographs, etc., illustrating local geographical phenomena, should be forwarded with the above..

The first impression gained from a perusal of the scheme is that it is inordinately comprehensive. It is difficult to dispute this, but although the gathering of the information will be no easy task, the chief difficulty will lie in selecting what is of truly geographical importance. Nevertheless, it will surely be allowed that the usefulness of such a compilation is sufficient justification for the labour entailed.

In closing, permit me to remark that if any valuable research work is to be accomplished at the higher centres of education here, geographical instruction in schools must receive every encouragement, and, in this connection attention should be drawn to the fact that although geography has been introduced into the Junior Certificate Examination, candidates will not consider it advisable to select it until they are allowed to continue its study as a subject for Matriculation.

On the whole, however, there is certainly no occasion for dissatisfaction, for a survey of the progress of the subject in South Africa during the past two years leads to the conclusion that slowly but surely are being laid the foundations of a geographical education which shall be wide in range, scientific in method, and, let us hope, productive of much good, commercially, civically and culturally.

ON THE DISCRIMINATION OF THE GENERAL CONIC.

By Prof. John Patrick Dalton, M.A., D.Sc.

In the teaching of mathematics more than in that of any other subject we suffer from the influence of tradition. To within a few decades ago the subject was an ordinary item in the educational curriculum, justifying its position by the mental stimulus provided, and the consequent sharpening of the logical faculty; but with modern developments of applied science there has arisen a class of students—now forming the larger proportion of the mathematical classes of the Universities—who are interested in the subject, because it affords powerful methods of solving the technical difficulties encountered in their work. On these students methods of purely historical interest and discussions of more or less metaphysical nature are wasted. A mathematician, of course, cannot encourage the teaching of certain inadequate methods of comparatively recent origin unhappily termed "practical mathematics," for, if he is to be in a position to use mathematical methods with certitude and facility, the technician must be as rigorous as the theorist; but one should aim at developing the mathematical training of the technical students upon as broad a basis as possible, and ensuring that his methods are of wide applicability, while specialized processes of purely historical interest or of limited power should be relegated to a subordinate position.

These considerations strike one rather forcibly in connection with the study of Conic Sections. The importance of Conics is, as a whole, somewhat overrated, and much time that is spent studying ingenious corollaries to their fundamental properties could be more usefully employed otherwise. For the technical man has to deal more frequently with transcendental curves, or with algebraical functions of degree higher than the second; and, moreover, processes which gave Plato pleasure in the early days of geometry, or which delighted Des Cartes when he inaugurated analysis, are not necessarily those best adapted to present needs.

Conics, like other curves, should be studied by means of their slope, and, having once defined a differential coefficient, tangent and normal properties ought to be deduced by its means, and not by repeatedly proceeding to a limit. The object of the present paper is to show how the discrimination of the general conic may be effected from consideration of its slope by methods such as could be usefully and effectively employed in the discussion of higher curves.

General Conic—Co-ordinates of Centre.—Students first obtain an idea of the shapes of conics from the usual locus definitions, and, in particular, their attention is drawn to the double and single symmetry respectively of the central and non-central curves. The general quadratic function—

$$S = ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0 \qquad (1)$$

is then taken in hand. Its slope is

$$\frac{dy}{dx} = -\frac{\frac{\delta S}{\delta x}}{\frac{\delta S}{\delta y}} = -\frac{ax + hy + g}{hx + by + f.} \qquad (2)$$

The locus

$$\frac{dy}{dx} = -\lambda \qquad (3)$$

where λ is any constant, is a straight line joining points on the curve, at which the slope is the same. For all values of λ the line passes through the intersection of the lines

$$\frac{\delta S}{\delta x} = 0 \text{ and } \frac{\delta S}{\delta y} = 0. \qquad (4)$$

It follows from considerations of symmetry that the intersection of these lines must be the centre of the conic. Solving equations (4), the co-ordinates of the centre are obtained

$$x = \frac{\begin{vmatrix} h & g \\ b & f \end{vmatrix}}{\begin{vmatrix} a & h \\ h & b \end{vmatrix}}; \quad y = \frac{\begin{vmatrix} g & a \\ f & h \end{vmatrix}}{\begin{vmatrix} a & h \\ h & b \end{vmatrix}} \qquad (5)$$

Non-central Conic.—If $ab = h^2$, then the centre of the conic recedes to infinity; that is the case of single symmetry. Equation (1) takes the form

$$(\alpha x + \beta y)^2 + 2gx + 2fy + c = 0. \qquad (6)$$

while its slope at any point is

$$\frac{dy}{dx} = -\left(\frac{\alpha}{\beta} + \frac{g - \frac{\alpha f}{\beta}}{\alpha\beta x + \beta^2 y + f}\right) \qquad (7)$$

Parallel Straight Lines.—When g and f both vanish, the slope of the non-central conic is single-valued and constant; hence it degenerates into a pair of parallel straight lines.

Parabola: Its Vertex and Axis.—When g and f do not vanish simultaneously, the slope is a function of the co-ordinates, and the curve becomes a parabola. The slope at infinity is $-\frac{\alpha}{\beta}$; the axis of the curve is therefore parallel to the line $\beta y + \alpha x = 0$. Chords perpendicular to the axis are given by $\alpha y - \beta x = \mu$. The value of μ, which makes this line a tangent, is easily found to be

$$\frac{(f\beta + g\alpha)^2 - c(\alpha^2 + \beta^2)^2}{2(f\alpha - g\beta)(\alpha^2 + \beta^2).}$$

This gives the tangent at the vertex, and from it the co-ordinates of the vertex, and the equation to the axis are easily obtained.

The Central Conic.—If $ab - h^2$ is not zero, the co-ordinates of the centre of the conic are finite. Transform the equation to parallel axes through the centre, and it becomes

$$S' = ax^2 + 2hxy + by^2 + c' = 0 \tag{8}$$

where

$$c' = a\bar{x}^2 + 2h\bar{x}\bar{y} + b\bar{y}^2 + 2g\bar{x} + 2f\bar{y} + c, \tag{9}$$

$\bar{x}$ and $\bar{y}$ being the co-ordinates of the centre.

The slope of the central conic is then

$$\frac{dy}{dx} = -\frac{ax + hy}{hx + by} = -\frac{h}{b} + \frac{h^2 - ab}{b\sqrt{h^2 - ab - \dfrac{c'b}{x^2}}} \tag{10}$$

Two intersecting Straight Lines.—If $c' = 0$, the slope is double-valued, and is independent of the co-ordinates. Subject to this condition, therefore, the equation becomes

$$ax^2 + 2hxy + by^2 = 0. \tag{11}$$

and must represent two straight lines of different slopes, and therefore intersecting. The condition may be written in the form

$$gx + fy + c = 0, \tag{12}$$

and therefore

$$2fgh + abc - af^2 - bg^2 - ch^2 = 0. \tag{13}$$

Tangent at Infinity. Hyperbola and Ellipse.—If c' does not vanish, the slope is a function of the co-ordinates. The slope of the tangent at infinity is, from (10)

$$\frac{dy}{dx}_{x \to \infty} \longrightarrow -\frac{h}{b} \pm \frac{1}{b}\sqrt{h^2 - ab}. \tag{14}$$

If $h^2 > ab$, these values are real, and the conic is a hyperbola; if $h^2 < ab$, they are imaginary, and the conic is an ellipse.

Axes of a Central Conic.—The method of (1) is again applied to determine the axes of a central conic, $S' = 0$. With the same centre describe a circle—

$$C = x^2 + y^2 = r^2. \tag{15}$$

The slope of the conic is

$$\frac{dy}{dx_s} = -\frac{ax + hy}{hx + by} \tag{16}$$

The slope of the circle is

$$\frac{dy}{dx_c} = -\frac{x}{y}. \tag{17}$$

The locus

$$\frac{dy}{dx_s} = \frac{dy}{dx_c} \tag{18}$$

or,

$$hy^2 - hx^2 = xy(b - a) \tag{19}$$

according to (11) represents two intersecting straight lines passing through the origin, and from (18) they must be lines passing

through pairs of points on the conic and circle where the slopes are identical. From symmetry they must, therefore, be the axes.

Asymptotes of Hyperbola.—Since the asymptotes pass through the centre their equation, deduced from (14), must be

$$\left[\left(y + \frac{h}{b}x\right) + \frac{1}{b}\sqrt{h^2 - ab}\,x\right]\left[\left(y + \frac{h}{b}x\right) - \frac{1}{b}\sqrt{h^2 - ab}\,x\right] = 0. \tag{20}$$

that is $$ax^2 + 2hxy + by^2 = 0. \tag{21}$$

TRANSACTIONS OF SOCIETIES.

South African Society of Civil Engineers.—Wednesday, October 13th: R. W. Menmuir, A.M.I.C.E., Vice-President, in the chair.—"*The application of reinforced concrete to small conduits for irrigation purposes*": J. C. **Hawkins** The author described the design and construction, and furnished particulars with regard to the costs of furrow linings, flumes, and siphons constructed in reinforced concrete, in the Gamtoos River Valley, Division of Humansdorp, Cape Province.

South African Institution of Engineers—Saturday, February 12th: W. Ingham, M.I.C.E., M.I.M.E., President, in the chair.—"*Belt Conveyors*": A. **Robertson** and A. McA. **Johnston.** The authors discussed the transport of materials by means of endless bands and their accessories, and, in particular, the handling of specific materials taken from gold and base metal mines which have to be transported in accordance with established mining practice, and to suit local and climatic conditions.—"*A pre-heated blast cupola*": J. A. **Parsons.** A type of cupola was described in which the air blast, instead of being cold when coming into contact with the column of coke which is ordinarily placed within the furnace on the kindling wood, is passed through a series of tubes in the top or chimney of cupola, and reaches the coke bed, after the blast has been on for some twenty minutes, at an increased temperature over one-third of the total temperature to be imparted to the iron. It was claimed that such a cupola economised coke, improved the quality of the metal, prevented by the slagging up of the *tuyères*, permitted of a temporary holding up of the furnace, was cheap and easy to manufacture, and possessed a capacity much in excess of that of the ordinary cupola.

South African Institute of Electrical Engineers.—Thursday, February 17th: Prof. W. Buchanan, M.I.E.E., President, in the chair.—Presidential address: Prof. W. **Buchanan.** A review was given of the life and work of Lord Kelvin, with personal recollections of his activities in the science and practice of electricity.

Chemical, Metallurgical and Mining Society of South Africa.—Saturday, February 19th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair. "*The conglomerates of the Witwatersrand*": Dr. E. T. **Mellor.** The geological features of the Witwatersrand were comprehensively described in their bearing upon the conditions of deposition of the gold-bearing conglomerates, considerable attention being devoted to the sedimentary features of the conglomerates, their probable mode of origin and their relation to the other portions of the Witwatersrand system. The author proceeded to discuss the origin of the gold and its distribution within the conglomerate beds and throughout the Witwatersrand system. In conclusion, the author considered the bearing of his deductions on economic questions connected with the conglomerate, particularly in the Eastern Rand, which he held to be the most important goldfield at present awaiting development.

THE EFFECTS OF SNAKE VENOMS ON DOMESTIC ANIMALS, AND THE PREPARATION OF ANTI-VENOMOUS SERUM.

By David Thomas Mitchell, M.R.C.V.S.

From time immemorial, and among all races, even where a fairly advanced state of civilisation existed, snakes have been looked upon as objects of dread and typifying mystery and wisdom. In more recent years, the progress of science has to a great extent dispelled the feeling of fear and repulsion which is associated with snakes, but yet it is impossible to regard without feelings akin to dread an animal which is capable of biting and causing changes which may result in the death of even the strongest animal in a very short space of time.

The nature and mode of action of the more common snake venoms has been the subject of careful research in the last quarter of a century, and the results have been very hopeful. It has been found that the active principles of snake venoms are soluble proteids belonging to the same class as enzymes and toxins. It has also been ascertained that immunisation can be carried out in the same way as in the immunisation of animals against contagious diseases, and that the serum taken from animals so immunised possesses anti-venenes which are specific. In order, therefore, to be successful in the treatment of snake-bite with such serum, it is necessary to have some idea of the species of snake which has inflicted the bite. For this reason I propose, before entering into the question of venoms and anti-venomous serum, to give a short classification of venomous snakes.

Reptiles of the order Ophidia, to which snakes belong, are distinguished by their elongated limbless bodies covered with horny epidermal scales, by their extremely flexible mouth, by the absence of eyelids, of a tympanic cavity and external ear openings, by having the cloacal orifice transverse and the penis paired,

For the accurate identification of the various families and genera it is necessary to be acquainted with the terminology of the scales, especially those covering the head, and also to know something about the skull and dentition, but as this would take up too much space, it is not my intention to enter into this subject in detail.

There are about 1,700 species of snakes known, of which some 300 have efficient poison fangs, and so must be classed as venomous, while 300 more possess a type of grooved tooth, and, therefore, while they cannot in the true sense be called venomous, as they are capable of instilling a secretion—whether saliva or venom—into the wound made, they must be regarded with suspicion. These species are distributed among nine families, two of which include the venomous and suspicious species. In the light of past experiences it is well, however, to avoid completely ignoring those varieties which are looked upon as harmless.

The two families to which the poisonous (Thanatophidia) snakes belong are the Colubridæ and the Viperidæ. In both of these the central shields are so elongated transversely that their ends can often be seen in a dorsal view, except in the case of some of the aquatic Colubridæ. The Colubridæ are identified by the following features:—

The head is covered by large, symmetrically arranged shields. The ventral shields are very much broadened transversely. The maxilla is horizontal, and in many species carries a number of teeth. The family is divided into three sections, according to the form of the teeth, namely, *Aglypha*, *Opisthoglypha*, and *Proteroglypha*.

1. In the Aglypha the maxilla is long, and carries numerous teeth, none of which are grooved. All the Aglypha are harmless, as not only is the special injecting apparatus absent, but the secretions of those which up to the present have been investigated, have proved innocuous when injected into small animals.

2. In the Opisthoglypha the maxilla is long and carries many teeth, of which a few of the posterior ones carry a longitudinal groove on the anterior border, the groove being very open. This family possesses a gland which is homologous with the poison gland of venomous snakes, and as the secretion is toxic for small animals, the family must be looked upon as suspicious.

3. In the Proteroglypha the maxilla is comparatively short, and teeth are few. One or two of the anterior teeth in the maxilla are very much enlarged, and constitute the poison fangs. These are so deeply grooved in some cases as to appear tubular. All this family are poisonous, although, owing to the variations in toxicity of the venom, death may not occur in all animals bitten. The base of the poison fang is in communication with a duct leading from a highly specialised poison gland behind the orbit.

The Proteroglypha Colubrines are subdivided into Hydropinæ and Elapinæ. These are distinguished by the following characteristics: The Hydropinæ are sea snakes, the tail of which is compressed like the blade of a paddle, and the poison fangs are placed in the front of the upper jaw. A few of the species may be found on the shore, and in these it will be found that the ventral shields are large, and the nostrils superior. The venom of these Hydropinæ is extremely toxic, and is looked upon as the most virulent known.

In the other sub-family—the Elapinæ—the tail is of the ordinary tapering cylindrical form. The head is covered with large shields, and the central shields are enlarged transversely.

The other family of the Thanatophidia—the Viperidæ—is distinguished by the short, freely movable maxilla, which is capable of being erected into a perpendicular position, and carrying large tubular poison fangs, which are the only teeth attached to the maxilla. There is a bunch of unattached, small reserve poison fangs immediately behind each main poison fang. It is customary to suppose that the Viperidæ can be distinguished from the Crotalinæ by the presence of a broad head covered with small scales,

a narrow neck, an elliptical pupil, and the short stumpy tail, but these points are not constant, and a further few Colubrinæ also exhibit these features.

The Viperidæ are divided into two sub-families, viz., Viperinæ and Crotalinæ. These are distinguished from each other by the presence of a large sensory pit in the Crotalinæ, named the loreal pit, which is a paired fossa placed between the eye and the nostril.

In the classification of snakes it must be remembered that colour is a very unreliable guide, as markings and colour may vary considerably in the same species in different localities.

The Venom Apparatus.

Venom is secreted by a pair of glands which are placed at the position of the parotids of other animals, and with which they are regarded as homologus. All snakes possess glands in this position, but the glands of the poisonous varieties are much more developed, particularly in their posterior extremity. These glands are surrounded by a fibrous capsule, and are covered by the masseter muscle, which has an insertion into the capsule, so that in the process of biting, the gland is forcibly compressed. Connected to each gland, and enclosed in its capsule, is an excretory duct which runs along the outer side of the upper jaw, and terminates in a slit-like opening at the base of the poison fang. This opening is in some snakes controlled by a sphincter muscle, and is in contact with, but not attached to, the lower opening in the poison fang. The venom is expressed from the gland at the moment of biting by the contraction of the neighbouring muscles, passes along the duct, entering the canal in the fang, and is injected into the part bitten. Not only is this expulsion due to muscular contraction of the muscles surrounding the gland, but in some snakes it would appear that the gland substance itself contained some muscular fibres. Thus, if the glands of the night-adder (*Causus rhombeatus*) be excised, and the venom allowed to flow out by holding the gland by the apex, it will be noticed that in a few moments a series of muscular contractions will set it, causing the ribbon-like gland to become distorted, and the venom will be freely expressed.

The fang is a modification of the grooved tooth previously referred to, the open groove on the anterior surface having now become—by an infolding and fusion of its free borders—a canal with the ends only open. In some of the Hydropinæ the fusion of the edges is not complete, but in the other Thanatophidia the only openings present are one near the base to which the end of the orifice of the poison duct is applied, and another near the free extremity of the fang.

Quantity of Venom.

The amount of venom which can be obtained at one time from a snake depends on a number of factors, *viz.,* the species, condition and size of the individual, whether the animal is fasting

or full, whether it has bitten recently or not, and whether it has been for a long time in capitivity or not. The largest amount can possibly be obtained from the King Cobra, and the smallest from some species of Hydropinæ. 200 mgs. of dried venom, representing about 670 mgs. of venom, have been obtained from a cobra (*Naja Haje*) in an experiment lasting over a period of four months.

Chemical and Physical Properties of Venom.

The different venoms vary very much in physical characters. Cobra venom is a clear, yellowish fluid, slightly viscid, and may sometimes be slightly opaque owing to the presence of epithelial scales. It is practically odourless, has a disagreeable taste, a very high specific gravity, and is acid in reaction. When dried rapidly in the desiccator, it solidifies into a transparent layer resembling gum arabic, this layer cracking in various directions on further desiccation.

The venom of *Crotalus* varies from a pale emerald green to orange or straw colour, and when dried resembles dried albumen. It has neither taste nor smell.

In this condition venom can be kept indefinitely, if protected from light, air, and moisture. It is freely soluble in water, and the resulting solution retains all the original properties of the venom. Venom owes its virulence to the presence of soluble proteids, some of which—especially those which predominate in the venom of the Viperidæ—are coagulated and partly destroyed by heat, and are completely destroyed by gastric juice. Others—principally those which predominate in the venom of the Colubridæ—are unaffected by gastric digestion or heat under boiling-point. All are, however, destroyed by pancreatic juice and prolonged boiling. Strong caustics, and strong oxidising agents which destroy proteids, or precipitate them from solution, render venoms inert. Of such agents hypochlorite of lime and permanganate of potash are good examples.

General Actions of Venoms.

The general actions of venoms have been studied by numerous observers. The ancients recognised snakes which they described under the names of *Echis* and *Colubra*, and their methods of treatment were based on attempts to prevent absorption, namely, ligation, scarification, and subsequent cupping or sucking of the wounds made. The effects of viper bites on animals were studied experimentally in the sixteenth century by Ridi and Morse Charas, and the important fact that the venom produced coagulation of the blood in animals bitten was noted. These workers came to the conclusion that the coagulation was the cause of death.

Weir Mitchell and Reichert, in 1886, published a very comprehensive paper in which they stated that the active principles of snake venoms were globulins and peptones. This was later confirmed by Wolfenden, and Karlbach, and the theory of the

alkaloid nature of venoms propounded by Blyth and Gautier was disproved. In 1892 Martin and Smith, studying the venom of Australian snakes, came to the conclusion that the venom contained three proteids, a hetero- and proto-proteose, and an albumen, the hetero-proteose alone being virulent.

During this period, which may be termed "the one-venom period," there was a general belief that all snake venoms had virtually the same active principles, which were thought to be of a proteid nature, and that differences in the effect produced in animals bitten were principally due to variation in amount of venom injected, thus being merely a quantitative difference.

The next period, which may be termed "the period of more than one venom," extends up to the present time, in which it is considered that there are at least two separate types of venom, one of which may be called the Viperine type, having as its example *Vipera Russellii*, and the other the Colubrine type, which may be exemplified by the *Naja tripudians*. There are, in addition, however, venoms which show characteristics of both types, and in which either the Colubrine or Viperine element may predominate.

It was shown by Reichert and Weir Mitchell that there was a considerable difference between the venoms of Viperinæ and Colubrines, and Martin, working with a Colubrine (*Pseudechis*), discovered that the venom produced intravascular clotting, and suggested this action as an explanation of sudden death resulting from the venom of *Vipera Russellii*. This theory was later confirmed by Lamb and Hanna.

In 1902 Flexner and Noguchi published a paper on venoms, showing that, in addition to the neurotrophic principles, venom contained separate lysins for the erythrocytes and leucocytes, and agglutinins for the erythrocytes and leucocytes, which were probably identical.

They also noted that venom contained hæmorrhagins, and lessened the bacterial action of the blood.

The work of various investigators has shown that snake venoms are very complex liquids containing some of, but not all in any one venom, the following active principles:—

(1) Neurotoxins—
  (*a*) Acting principally on the respiratory centre;
  (*b*) Acting principally on the vaso-motor centre;
  (*c*) Acting principally upon nerve and plates in striated muscle, particularly in those of the phrenics
(2) Agglutinins.
(3) Cytolysins—
  (*a*) Hæmolysins;
  (*b*) Leucolysins.
  (*c*) Hæmorrhagins.
(4) A fibrin ferment.
(5) A proteolytic ferment.
(6) Antibactericidal substances.

Of these the more important are the neurotoxins, the cytolysins, and the fibrin ferment. These various active principles will now be considered briefly.

Neurotoxins.–The neurotoxins are the most important active principles of many snake venoms, especially those of the Colubrine type. They have been studied in the *Ancistrodon contortrix* by Flexner and Noguchi, who tested the power for anchoring of the various tissues in the body for venom. As a result of their experiments it was found that while the control guinea-pig died in 45 minutes after injection of two minimal lethal doses, when three minimal lethal doses were emulsified with two grammes of brain substance, incubated for an hour, centrifugalised, and the supernatant fluid collected and injected into a guinea-pig, death did not occur for 19 hours, and when two minimal lethal doses were used the guinea-pig survived. From these experiments it was concluded that snake venom contained a neurotoxic principle, which is the principal toxic element, and which unites the multiple minimal doses with the nerve cells; but even when this neurotoxic principle is removed, there is still sufficient hæmolysin left to produce fatal results. Rodgers has shown that this neurotoxic substance—in the cobra and Hydropinæ—when given in small doses, causes a temporary stimulation, and in large doses attacks the respiratory centre, and causes the respirations to become slower and less in amplitude minute by minute, until they eventually cease. He also has shown that paralysis of the end plates of the phrenic nerves in the diaphragm occurs soon after failure of the respiratory centre. In the medulla neurotoxins do not seem to affect the blood pressure; in fact, the circulation can be kept going by artificial respiration for a long time.

The neurotoxins in Viperine venom, on the other hand, were shown by Rodgers to act on the vaso-motor centre in the medulla, causing a variation in blood pressure. It will thus be seen that there are in snake venom two groups of neurotoxic elements.

(1) Colubrine neurotoxic elements, acting on the respiratory centre of the medulla, and on the end plates of the phrenic.

(2) Viperine neurotoxic elements, acting on the vaso-motor centre.

The agglutinins present in venom can be demonstrated *in vitro* by adding to a series of test-tubes containing normal saline and washed corpuscles a solution of venom varying in strength from 0.01 per cent. to 10 per cent., and placing in the thermostat. Agglutination occurs at a time varying according to the concentration of the venom solution. These agglutinins can be destroyed by heating to 80 degrees Centigrade.

The cytolysins were shown by Flexner and Noguchi to be of the nature of amboceptors which require a complement, which is obtained in the serum of the victim. Hence they are capable of not only producing hæmolysin, but also diminishing the bacteriolytic action of the blood. Further research on this subject by Kyes and Sachs showed that while in the ox, sheep and goat

hæmolysis could be produced in the presence of venom by the addition of complement, in the horse, man, dog, rabbit, and guinea-pig the venom alone could hæmolyse the washed corpuscles, and they came to the conclusion that there was an endo-complement present in the red cell itself, attached to the stroma.

They concluded, further, that it is the lecithin of the stroma which acts as a complement. Kyes found that the lecithin was active with the blood cells of all the species which he examined, and that the quantity necessary for hæmolysis was the same for the blood cells for the various species of animal.

At present it is therefore considered that snake venom produces hæmolysis by its amboceptors uniting with the complements contained in the sera of the majority of animals, and that these complements belong to the class of fatty acids and soaps, and, further, that in certain species there are endo-complements in the erythrocytes attached to the stroma of the corpuscles of the same nature as those in normal sera.

Hæmorrhagin.—Investigations into the action of Crotalus venom showed that when this venom was applied to the mesentery, blood escaped from the vessels owing to damage to their walls. Flexner and Noguchi, working in this connection, found that this property was lost if the venom was heated to 75 degrees Centigrade for 30 minutes, and they named the toxic principle hæmorrhagin.

Its action was studied by intra-peritoneal injection of venom and subsequent examination. It was found that the extravasation of blood produced was not due to diapedesis, but to actual rupture of the walls, apparently due to a cytolytic action of the venom on the endothelial cells of the capillaries and smaller veins.

Fibrin Ferment.—A fibrin ferment was shown to be present in the venoms of the Viperidæ, and also in some of the Colubridæ by Martin. In the former it is the active principle which causes intravascular clotting in small animals, associated with sudden onset of convulsions and death.

Nature and Action of Venoms.

From a biological point of view, venom may be regarded as essentially part of the digestive mechanism, and to an animal which swallows its prey with the integument intact, it is of considerable advantage to be able to impregnate it with powerful solvents and ferments. It is generally agreed that in the venom of the Colubridæ, neurotoxins, with a specific affinity for the respiratory centre, preponderate, and that in the Viperidæ toxins, which act on the blood and circulatory system, preponderate; while among Australian Colubrines venoms are found which are rich in both classes of toxins. In the Hydropinæ the venom is almost purely neurotoxic in effect.

It must be understood, however, that in any given venom, especially those which act chiefly on the blood system, one toxic

effect or another may be emphasised or marked according to the amount injected, and the rapidity with which it is absorbed.

Owing to the difficulty of obtaining information regarding the species of the snake which has bitten, under what may be termed "natural conditions," one has to resort to animal experimentation in order to form an idea of the symptoms produced by the various species. For this purpose I propose to detail the results produced on animals as a result of the bite of known species.

(1) *Colubrine Venom.*—The typical venom of this class is that of the *Naja tripudians,* and the effects produced by this venom are as follows:—Salivation, slowing and subsequent cessation of the respirations, which cease some considerable time before the heart stops. In smaller doses the paralysis becomes more marked, and as death does not rapidly ensue, the following additional symptoms become apparent. Local inflammation at the site of the bite, lachrymation, salivation, mucous discharge from the mouth and nostrils, which are occasionally blood-tinged, but there are no marked hæmorrhages from the mucous surfaces. There is obvious pain at the site of the bite, and engorgement of the vessels causing swelling, due to effusion into the tissues. In cases of recovery, the local lesion may suppurate and slough away. The most evident paralysis is that shown in the tongue, larynx and pharynx, causing salivation, inability to feed or swallow, due to the action of the venom on the medulla.

On *post-mortem* examination it will be seen that there is a considerable hæmolysis, and the coagulability of the blood is reduced. The tissues are blood-stained, and the urine blood tinged if the animal has survived for some time after the bite. Rigor mortis is well marked. There is congestion of the lungs and bronchial mucous membrane. The right heart is distended with blood, the liver dark and congested. The kidneys are congested, pulmonary œdema is common and is associated with congestion in some cases of the pulmonary tissue and bronchial mucous membrane. Intestinal hæmorrhages may be present, but are not common or extensive.

The predominant actions of Colubrine venom are therefore seen to be as follows:—General paralysis and special paralysis of the breathing mechanism, due to neurotoxin, and the more or less delayed onset of symptoms.

Observations on the effect of the bite of a few Colubrine snakes, including *N. haja, N. flava,* and *Sepedon hæmachates,* on animals were noted at Onderstepoort by Andrews, and the following is a *résumé* of the results obtained.

The clinical symptoms recorded were divided into groups.

A local swelling was sometimes present, which was either soft, insensitive and pendulous, or tense, hard and very sensitive to the touch. Out of seven animals bitten by *N. haja,* four died without showing any local swelling, but this was noted in the animals which recovered. Four animals bitten by *N. flava,* all died. A mule which died five hours after the bite developed a

hard painful swelling, and a horse which died after 42 hours showed a large, soft, insensitive swelling.

With *Sepedon hæmachates,* three horses bitten all developed a large painless local swelling and recovered. Resolution in these cases occurred without complications. It would appear that the formation of a large local swelling subsequent to the bite of Colubrine snakes denotes a subacute case which will probably end in recovery.

The effects of the local lesion were in most cases due to the pain and swelling, causing a limb to be carried or moved restlessly or causing mechanical interference with a joint, if in the region of one.

General symptoms due to pain were noted, *viz.,* restlessness, sweating, hurried respirations and a frequent hard pulse.

Nervous symptoms indicated by excitement or depression were present in some of the animals under observation. Symptoms of excitement were shown by the restless movements of the animal in the box, accompanied by excessive movements of the tail, head, and jaws. Quivering of muscles or even spasmodic contractions were in some cases observed, either local or general, and in the final stage of asphyxia there were in some cases general convulsions.

Other symptoms suggestive of excitement which were noted were as follows:—

Grinding of the teeth, frequent movement of deglutition, copious defæcation and urination, frequent deep respirations and a rapid pulse.

The symptoms of nervous depression were shown by a torpor varying from a slight dulness to paralysis, either local or general, and finally paralysis. The animal in the dull stage remains a long time in one position, with head hanging and the eyes closed. Co-ordination of movements are impaired and muscular tone is lost in voluntary and involuntary muscles.

In one horse and sheep bitten by *N. haja* general dulness and weakness was very marked, and in a horse bitten by *N. flava,* progressive paresis and incoordination of movement was well shown.

The general effects of Colubrine venom on domestic animals may be summarised as follows:—

A period of excitement occurs within an hour, and this is followed by a period during which the animal appears normal.

Muscular contractions develop in from one to a few hours, these becoming more and more intense, and the animal dies in a short period from asphyxia. Animals not succumbing rapidly to the effects of the venom exhibit a stage of general depression interrupted by periods of restlessness and motor excitement, and the condition frequently ends in death.

The *post-mortem* lesions found in animals which have died as a result of poisoning by Colubrine venom may be briefly stated as follows:—

Rigor is delayed; serious infiltration of the lesion may be present with a few hæmorrhages into the substance. The fluid in the serous cavities may be blood-tinged in the case of *N. flava*. Lungs may show sub-pleural hæmorrhages.

(2) *Viperine Venom.*—The action of venom of the *Vipera russellii* may be taken as a good example of this type of venom. The experiments by Wall in the dog with this venom show that death occurs very rapidly in five minutes, and *post-mortem* examination shows some intravascular clotting, especially marked in the portal vein. In smaller animals bitten by this snake, the intravascular clotting of the blood is very well marked. Hœmorrhages will be found into the area of the bite, and also in the kidney and into the intestine.

In cases where the dose injected is insufficient to kill rapidly, local symptoms appear, these being more or less extensive subcutaneous hæmorrhages and an area of profuse œdema. The extravasated blood may be absorbed and resolution occur without complications, or the part may slough or an abscess form, or spreading gangrene may follow. General symptoms may develop, of which the following are the most important:—

Rapid emaciation, profound anæmia and lethargy, hæmaturia, and occasionally intermittent discharge of blood-stained fæces. There is a fall in blood pressure due to vaso-dilation in the portal system, but no pronounced alterations in the peripheral circulation are seen. In chronic cases, Lamb and Hanna have pointed out a decrease in the coagulability of the blood. Cessation of respiration in fatal cases is due to failure of the circulation, but there is no direct effect on the respiratory centre, and the phrenics are not paralysed. The heart-beats are continued some time after the respirations have ceased, but their frequency and volume is very much diminished.

It will therefore be seen that Viperine venoms contain toxins which (1) particularly affect the blood and vascular systems, (2) cause sudden onset of symptoms, and (3) liability to extensive gangrenous destruction of the local lesion if the animal's life is prolonged beyond the acute stage.

The effects of Viperine venom on animals have been recorded by Andrews, who utilised the venom obtained from two species, *Bitis arietans* (puff-adder) and *Causus rhombeatus* (night-adder). His results may be summarised as follows:—

A local lesion was invariably developed, varying from an infiltration, only apparent on *post mortem*, to an enormous swelling. Its onset was rapid, and was in all cases appreciable one hour after the bite was inflicted, from which time onward it rapidly increased in size and tended to gravitate to dependent parts. The lesion was hot and painful to the touch, and resolution was slow. A discharge of fluid through the skin and sloughing was noted in one animal bitten by the puff-adder, and then only on being bitten a second time after recovery.

Symptoms of pain were pronounced in all cases, with the

exception of a horse bitten by *Causus rhombeatus*, which animal was only very slightly affected by the bite.

The nervous symptoms could not be easily distinguished from those produced by Colubrine venom. Depression occurred in the earlier stages, and this was later followed by twitching of the skeletal muscles, frequent defæcation and micturition, spasmodic contractions of the abdominal and limb muscles being noted in some cases. The pulse was frequent and weak, and the respiration laboured. Death was preceded by a comatose condition, in which stertorous breathing and a weak, infrequent pulse were the principal features.

No symptoms of incoordination of movement or paresis were observed.

In the *post-mortem* examination it was found that the tissues underlying the skin at the site of the bite were infiltrated and hæmorrhagic. Blood-tinged exudates occurred in the serous cavities. Hyperæmia of the lungs and bronchial tubes was present, and hæmorrhagic areas were present in the alimentary tract.

Examination of the blood obtained from animals recently bitten by *Causus rhombeatus* and *Bitis arietans* showed that the venom produced no hæmolysing effect on the corpuscles, nor was any diminution of coagulability of the blood apparent in blood acted on by the venom of *Causus rhombeatus*. A marked anti-coagulative effect was, however, produced in the blood of animals bitten by *Bitis arietans*.

Having now considered the composition and physiological actions of snake venoms, the next points which come to be discussed are immunity against venom and the preparation of anti-venomous serum.

Sewall in 1887 made the first scientific attempt to produce artificial immunity, when he immunised pigeons by repeated small doses of venom, so that they were able to withstand 10 minimal lethal doses of *Crotalus* venom.

Experiments on similar lines followed, and in 1892 Calmette showed that by repeated injections of venom, heated to 80 degrees Centigrade, a considerable amount of resistance could be produced in animals. Horses were utilised for these experiments, and a serum was produced later, 2 c.c. of which were capable of protecting a rabbit of two kilos. weight injected two hours later with one milligram of cobra venom. Control untreated rabbits, injected with a simiuar dose of venom only, succumbed in 30 minutes. Frazer, of Edinburgh, confirmed these results, and it was considered by him that this serum was capable of protecting against all venoms.

It was later shown by Lamb that, although Calmette's serum was active against cobra-venom, it was not useful against Viperine venom. He also showed that a precipitin was present in anti-venomous serum, and he assumed that these principles were specific.

The failure of Calmette's serum to protect against Viperine

venom was due to the fact that the venom used in its preparation, being of Colubrine origin, contained almost pure neurotoxin, and and practically no hæmorrhagin, which is the preponderating constituent in the Viperine venom.

Several pure sera have been from time to time prepared against the venom of particular snakes; the chief of these are as follows:—

Lamb's pure *Naja tripudians* serum, which is strongly antitoxic for cobra venom.

Lamb's pure *Vipera russellii* serum, antitoxic for Viperine venom.

Noguchi's pure *Crotalus* serum, antitoxic for Viperine venom, but having no effect on cobra.

Noguchi's pure *Ancistrodon* serum, antitoxic for Viperine venom, particularly *Ancistrodon*, but no effect on Colubrine venom.

The preparation of a polyvalent serum has been attempted with fairly successful results, but it is not yet possible to prepare a serum sufficiently polyvalent to satisfy all requirements.

Calmette obtained his serum from horses hyperimmunised against cobra venom in the following manner:—

Small doses of the venom with hypochlorite of lime were first injected subcutaneously. The quantity of venom was gradually increased and the hypochlorite diminished, and injections repeated every three or four days, administration being regulated by the condition of the animal. Later a heated mixture of cobra and adder venoms was used containing 80 per cent. cobra and 20 per cent. adder.

When the animal resists the injection of a minimal lethal dose, the injections are pushed rapidly and continued until the animal can withstand without ill-effects a subcutaneous injection of 2 grammes of dried cobra venom—that is, about 80 times the minimal lethal dose. During the immunisation many complications arose, such as endocarditis, acute nephritis and abscess formation. The time required for the immunisation under favourable conditions was about 16 months. Serum was obtained from an animal so treated, and tested, the serum being considered to be sufficiently antitoxic when 1 c.c. of serum mixed with 0.001 gramme of cobra venom produced no symptoms of intoxication on subcutaneous injection into a rabbit, and when 2 c.c. of serum injected into a rabbit of 2 kilos, protected it against an injection of 0.001 gramme of venom two hours later.

The results obtained from the use of Calmette's serum have been very good, but it must be remembered that the serum is almost purely anti-neurotoxic, and if successful results are to be expected it can only be used in cases of bite by Colubrine snakes.

The necessity of a serum which would protect against South African snakes primarily was realised in 1901 by Watkins-Pitchford, working in Natal, and he commenced the preparation

of antivenomous serum against the commoner varieties—namely, *Bitis arietans*, *Naja nigricollis* and *Flava* and *Sepedon hæmatochilus*.

Unfortunately the records of these earlier experiments are not available, but antivenomous serum of an activity equal to Calmette's for use against puff-adder and cobra was issued from the Pietermaritzburg Laboratory about 1903. Watkins-Pitchford employed horses and mules, and in the earlier stages the technique was based on that of Calmette, namely, subcutaneous injections of venom at definite intervals. It was found, however, that the quantity of venom required successfully to immunise a horse was so great that there was much difficulty in obtaining sufficient supplies, and, further, that this method, owing to the variable production of an extensive local lesion at the site of injection, could not be successfully carried out with puff-adder venom. It was, therefore, decided to endeavour to hyperimmunise the animals by intravenous injections of venom. This was done, and the results were so satisfactory that the method was adopted, and is still being utilised for the production of antivenomous serum. The advantages over the method of Calmette are: (1) That a very much smaller quantity of venom is required to produce serum having the necessary activity. (2) That it is now possible to produce an anti-viperine serum without delay due to abscess formation and other complications affecting the site of injection. (3) There is practically no loss of condition in the animals under treatment, such as was reported by Calmette. (4) The antivenomous activity of the serum is found on test to compare very favourably with that produced by Calmette.

The method, however, has two disadvantages—(1) the tendency to thrombosis of the vein into which the venom was injected; (2) the very acute reaction which follows almost immediately after the venom is injected, due to the very rapid distribution of the venom through the system. The details of this method are as follows:—

The animal selected should be young, but full grown and in good condition. Horses of a dull, lethargic temperament do not appear to stand the injections as well as those of a more spirited nature. The neck should not be fleshy, as in such cases if the venom accidentally gets into the subcutaneous tissue surrounding the vein a swelling results, and the vein becomes difficult to puncture.

The dose of prescribed venom to be injected is carefully weighed and dissolved with from 5 c.c. to 10 c.c. of distilled water, and sucked into a suitable syringe. A needle free from venom is then introduced into the jugular vein, which has been raised by digital pressure, the syringe is connected to the needle, and the piston is then raised until blood is drawn into the syringe. The pressure on the vein is released, and the contents of the syringe slowly injected. It is a good plan to have the jugular vein compressed so that a little blood is again sucked up into the syringe, which, when injected, ensures that all the venom solution

has been administered. The syringe needle is then withdrawn. Aseptic precautions must be observed throughout the operation. If the injection has been properly performed, no local lesion will develop; but if the venom is allowed through carelessness to come into contact with the subcutaneous tissue, a swelling will develop, which, if it does not result in abscess formation, will at any rate obscure the jugular vein, and render successive inoculations more difficult. These remarks apply in particular to the use of Viperine venom.

The reaction begins in about 30 seconds after the injection of the venom, and lasts from 15 minutes to one hour. The severity of the symptoms shown depend on the increase of dose given, and also on the specific idiosyncrasy of the animal. Very great differences have been observed in the resistance shown by various animals, some showing only slight reactions to a comparatively large increase of venom, others showing violent reactions after each inoculation.

The symptoms shown depend on the origin of the venom, whether Viperine or Colubrine, and the following are the more important symptoms of marked reactions in the order in which they appear:—

(1) Viperine (Puff-Adder).—Respirations temporarily increased, followed by a very marked slowing, which is frequently so marked that for a few minutes respiratory movements are almost unappreciable. General dullness and depression, head drops, and the blood in the jugular veins stagnates and causes them to become very prominent. The eyes close and the animal sways as though semi-comatose, in which conditions it often neighs. At this stage the animal may fall unless supported. The visible mucous membranes are injected, and the pulse rapid and intermittent. Stretching of the legs occurs, the limbs being alternately lifted and extended as though the animal was suffering from cramp. Spasm of the abdominal muscles is frequent. Later these symptoms may subside. Symptoms of colic appear, the animal turning its head towards its side, kicking the abdomen with its hind-legs. These do not usually last for more than 15 minutes. Free defæcation occurs, sometimes followed by slight diarrhœa, which may last for a few hours.

(2) Colubridæ (*Naja Flava* and *Nigricollis*).—The first symptoms observed after injections of cobra venom are inscribed respirations and turning up of the upper lip, indicating nausea, and general symptoms of excitement. There is quivering of the muscles of the limbs, especially marked at the flank and shoulder, and profuse sweating. The pulse is increased in frequency. Marked incoordination of movement is present, the animal staggering from side to side, crossing the legs, and in some cases falling to the ground unless supported. At this stage the breathing is laboured and chiefly abdominal. The nostrils are distended, the neck held low, with the head thrust forward. Acute symptoms of colic may develop later, the animal kicking at the abdomen and turning the head to the flank, but these

symptoms usually result in free defæcation which is not accompanied by diarrhœa, and the subsequent recovery is rapid. Mamba venom produces an acute and violent colic accompanied by increased peristalsis and frequent discharge of fæcal matter; later the discharge becomes fluid, and frequently death results.

For treatment of an animal during reaction, inhalations of ammonia seem to have a good effect, particularly in the case of the reaction following injection of puff-adder venom. The onset of the symptoms of colic can be to a great extent prevented by the administration of a bran mash on the evening preceding the injection.

The quantity of venom required to hyperimmunise a horse varies considerably, but in no case has the quantity exceeded 2 grammes. It would appear that the more severe the reaction produced, even in cases where the increase was comparatively small, the more rapid did the serum develop antivenomous properties. Owing to the variations in toxicity of venoms obtained from different sources, it will be found advisable to procure sufficient venom to complete the hyperimmunisation before commencing inoculations. These various venoms should be mixed together so as to obtain a mixture of constant toxicity, and thus one will be enabled to control the reactions resulting from an increased dose, and the increase can be regulated with more accuracy. The initial injection of venom should be regarded as a test of the animal's powers of resistance to the venom employed, and should in no case exceed one-quarter of the minimal lethal dose. As a result of a number of experiments, it has been ascertained that inoculations at 10-day intervals produce the most satisfactory results, and give rise to less risk of dangerous anaphylactic reactions. The rate of increase of the venom depends upon the susceptibility of the animal, and one has to be guided by the severity and duration of the resulting reactions. With cobra and adder venoms an initial dose of 5 mgm. can be given in most cases with safety. The increase at first must be slow, but will depend on the reaction developed, and after a few injections the animal will tolerate an increase of 5 to 8 mgm. at each injection. In the case of mamba, the initial injection must not exceed 2 mgm. and subsequent increases must be carried out carefully. In most cases it will be found that an animal will stand an increase of 2 mgm. at each injection, after some immunity has been developed; but it must be remembered that, as in the cobra and puff-adder, no definite lines can be laid down, and the reaction must serve as a guide.

The time necessary to produce a serum which will be sufficiently active depends to a great extent on the animal, as immunity, and as a result more active serum, develops more quickly in some horses than in others. In the case of animals being hyperimmunised against cobra and adder, the serum will be found to be sufficiently active when the animals stand an intravenous injection of 75-100 mgm. of described venom. It is the practice to test the animal's serum when no reaction occurs after an injec-

tion of 50 mgm., and thus to obtain some idea of its antivenomous properties.

The serum is considered to be ready for issue when 1 c.c. mixed with 1 mgm. of venom produces no symptoms on being injected into a rabbit; and when 2 c.c. of serum protects a rabbit of 2 kilos. against an injection of 1 mgm. of venom two hours later.

This is a rough-and-ready method, and gives no idea of the actual valency of the serum, so, in order to obtain definite information on this point, it is necessary to carry out a series of tests on rabbits to ascertain the amount of serum required to protect against a minimal lethal dose per kilo. of venom to be used for test purposes. Owing to the wide variations in toxicity which occur in venoms collected from different snakes, it is necessary to ascertain previously the minimal lethal dose per kilo. of rabbit by experiment, otherwise the results of the serum test cannot be taken as absolutely accurate. As a guide I give herewith the minimal lethal dose of venoms from the more common poisonous South African snakes. The figures have been compiled from a series of experiments carried out on rabbits at Pietermaritzburg Laboratory:—

		Minimal Lethal Dose per Kilo.	
Snake.	Animal.	Intravenous.	Subcutaneous.
		mgm.	mgm.
Bitis arietans	Rabbit	0.5	1.7
Dendraspis	,,	0.225	0.325
Naja nigricollis	,,	0.9	1.25
Naja flava	,,	1.5	2
Causus rhombeatus	,,	4	7.5
Sepedon hæmachates	,,	0.21	3

In the intravenous method of antivenomous serum production, serum can be produced of more than three times the activity necessary to fulfil these conditions. This is specially the case in Viperine antivenene.

A polyvalent serum has been prepared at the Pietermaritzburg Laboratory against mamba, puff-adder, and cobra venoms, and the results in the case of the two latter snakes' venom have been extremely satisfactory. No opportunity, so far as I am aware, has ever occurred for testing its efficacy against mamba venom, and as applications for serum containing mamba are so rare, this venom has now been omitted from antivenene work. The preparation of a polyvalent serum requires more time, and its production is attended with more risk of death of the animal being hyperimmunised than in the case of serum prepared against one species of snake. It is also difficult to obtain maximum activity of all its components, and it is often found on test that one or other is deficient. I am therefore of the opinion that a much more constant and efficacious polyvalent serum could be prepared by mixing monovalent sera of maximum valency.

This, so far as I am aware, has not yet been tried, but I see no reason why the results should not be successful. The method

would undoubtedly simplify polyvalent antivenomous serum production.

Animals whose serum has been tested and found up to standard, are bled ten days after the last injection. The quantity of blood taken depends on the size and condition of the animal, but averages 7 litres. The animal can be bled twice later at five-day intervals, and 4 to 5 litres taken at each bleeding. Ten days after the last bleeding, injection of venom can be recommenced, and the administration can now be more rapidly pushed than on the former occasion.

The serum collected from the blood taken is distributed under aseptic conditions into ampullæ of 25 c.c. capacity, which are hermetically sealed. These ampullæ are heated in a serum inspissator for one hour at a temperature of 58° C. on three successive days, in order to ensure absolute sterility. The serum thus prepared will retain its antitoxic properties unimpaired for about two years if kept from sunlight and stored in a cool place.

After some time the serum becomes changed owing to the deposit of albumen, which settles to the bottom on standing, in the form of flakes. This deposit is partly redissolved on shaking, and its presence is not a sign of deterioration of the serum.

Each ampulla contains one dose of serum. When required for use, part of one or two doses is injected as soon as possible, with a hypodermic syringe, into the subcutaneous tissues of the flank, and the remainder into the tissues around the bite. If delay has occurred and absorption has taken place, it is best to inject all the serum into the flank, or in cases where symptoms of serious collapse are present, it is preferable to inject the serum directly into one of the large veins, the most suitable being those of the inner side of the forearm just below the elbow.

If this method is carried out, it is necessary to avoid injection of sera containing flocculi, either by careful decantation of the clear supernatant fluid or filtration through filter paper.

Antivenomous serum can be desiccated, and in this form is much more portable, and it has the additional advantage of retaining its antitoxic properties indefinitely if kept hermetically sealed. Experiments carried out with desiccated serum prepared against puff-adder venom at Pietermaritzburg Laboratory have shown that it is not only equal in activity in fresh solution to puff-adder antivenomous serum, but also, if used locally in the dried form after free incisions into the area bitten, its action is much more rapid in neutralising the injected venom than permanganate of potash.

Serum on desiccation becomes reduced to about one-eleventh of its original volume, and thus 2 grammes of the powder are equal to about a dose of the serum.

When required for use the powder can be added to 20 c.c. of water which has been boiled and cooled, in which it fairly readily dissolves, and injected in the same manner as antivenomous serum.

The preparation of desiccated antivenene is as yet only in the experimental stage, but the advantage which it has now over the ordinary antivenomous serum, and the success which has been experimentally obtained with its use in the general and local treatment of snake-bite, leads one to believe that its success in practice is assured.

In the case of snake-bite, even where antivenomous serum has been administered, it must be remembered that local treatment of the area bitten is also necessary. Ligation where possible, and free incisions into the site of the bite by preventing or delaying absorption, will assist in preventing onset of the symptoms produced by the venom until such time as the serum injected has had time to exert its action.

Treatment of the general symptoms must also be carried out, but a discussion on these points does not come within the scope of this paper.

THE STRUCTURE OF THE UNIVERSE.—The *Journal of the Astronomical Society of India** contains an address by the Hon. W. A. Lee, F.R.M.S., President of the Society, on "The centre of the visible universe." Mr. Lee points out that the direction of the centre from our system corresponds very closely with the direction of Canopus. He estimates the distance of the centre from us at 400 light-years, while the distance of Canopus is calculated as nearly 500 light-years. He declares that the enormous mass which Canopus is reckoned to possses—probably, 1,400,000 times that of our sun—is such as to account for the latter's motion in space crosswise to Canopus, namely 3.86 miles a second, or just the speed which would result from the movement of our sun in an orbit round Canopus if the mass of the latter star were as above stated. J. H. Jeans, using the phenomenon of star-streaming as a means of exploring the structure of the universe, comes to the conclusion† that all hope must be abandoned of unravelling the mechanism of the universe by assuming it to be in a steady state. Our direct observational knowledge of the movements in our universe is so limited that any attempt to explain star-streaming as a steady state phenomenon must inevitably fail. At most we may regard star-streaming as a motion of parts of the universe in process of taking up the position or motions which they will ultimately have in a steady state which has not yet been attained.

* **6** (1915), 6-11.
† *Monthly Notices, R.A.S.*, Dec., 1915.

NOTE ON THE INTERSECTION OF TWO CURVES, WHOSE EQUATIONS ARE GIVEN IN POLAR CO-ORDINATES, WITH AN ILLUSTRATIVE EXAMPLE.

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(*With two text figures.*)

1. The point with coordinates (r, θ) may also be written as the point $(-r, 180^\circ + \theta)$. From this it follows that the intersections of two curves $f(r, \theta) = 0$, $F(r, \theta) = 0$ are not necessarily completely given by finding the points on the two curves for which the r and the θ are the same, the points (r_1, θ_1) on the first and (r_2, θ_2) on the second, for which $r_2 = -r_1$, $\theta_2 = 180^\circ + \theta$, must also be considered. I have not seen this mentioned, though it is implied in the standard question, to find the equations of two common chords of $\frac{l}{r} = 1 + e\cos(\theta - \gamma)$, $\frac{L}{r} = 1 + e'\cos(\theta - \delta)$.*

An illustrative example is the intersection of two conics with a common focus and axes perpendicular, whose equations may be written $\frac{l}{r} = 1 + e\cos\theta$, $\frac{l'}{r} = 1 + e'\sin\theta$. The points for which $r_1 = r_2$, $\theta_1 = \theta_2$ are given by $l'(1 + e\cos\theta) = l(1 + e'\sin\theta)$, *i.e.*, $e'l\cos\theta - e'l\sin\theta = l - l'$. This equation can only give two values of θ between 0° and 360°, and therefore only two points of intersection of the conics. The other points of intersection are those for which $r_2 = -r_1$, $\theta_2 = 180^\circ + \theta_1$, and are given by $\frac{l}{r_1} = 1 + e\cos\theta_1$,

$$\frac{l'}{r_2} = 1 + e'\sin\theta_2,\ r_2 = -r_1,\ \theta_2 = 180^\circ + \theta_1,$$

$$\therefore \frac{l'}{-r_1} = 1 - e'\sin\theta_1$$

$$\therefore \theta_1 \text{ is a root of } l'(1 + e\cos\theta) = -l(1 - e'\sin\theta),$$
$$\textit{i.e.},\ el'\cos\theta - e'l\sin\theta = -l - l'.$$

No root of this equation can be also a root of the other equation, or differ from a root of that equation by 180°.

It may be noted that the points for which $r_1 = r_2$, $\theta_1 = \theta_2$ lie on

$\frac{l - l'}{r} = e\cos\theta - e'\sin\theta$, one chord through two points of

* Clement-Jones, *Introduction to Algebraical Geometry*, p. 379.

intersection and the points for which $r_2 = -r_1, \theta_2 = 180^\circ + \theta_1$ lie on $\dfrac{l+l'}{r} = e \cos\theta + e' \sin\theta$, another chord through two points of intersection. Both these chords pass through the intersection of the directrices corresponding to the common focus.

2. The points of intersection of $f(r, \theta) = 0$, $F(r, \theta) = 0$ may be completely given by finding the points on the two curves for which the r and the θ are the same.

For example, $r = 2\,a \cos\theta$, $r \cos\theta = a$ have all their intersections given in this way. In their cases, the points (r_1, θ_1), $(-r_1, 180^\circ + \theta_1)$ are both given on the curves, and each equation is unaltered by writing $-r$ for r and $180^\circ + \theta$ for θ.

Again, the curves $\dfrac{l}{r} = 1 - e \cos\theta$, $r = 2a \cos\theta$ have all their intersections given in this way. These points are given by $2ae \cos^2\theta + 2a \cos\theta = l$, and the roots of this equation in θ are α, $360^\circ - \alpha$, β, $360^\circ - \beta$, say; for each there is a corresponding value of r given by $r = 2a \cos\theta$. The points for which $r_2 = -r_1$, $\theta_2 = 180^\circ + \theta_1$ are given by $\dfrac{l}{r_1} = 1 + e \cos\theta_1$, $r_2 = 2a \cos\theta_2$, $r_2 = -r_1$, $\theta_2 = 180^\circ + \theta_1$.

$$\therefore \frac{l}{r_1} = 1 + e \cos\theta_1,\ -r_1 = 2a \cos(180^\circ + \theta_1),\ i.e.,\ r_1 = 2a \cos\theta_1,$$

$\therefore$ the equation for θ_1 is the former equation for θ and the points of intersection found are the former points.

In general, if the substitution of $-r$ for r and $180^\circ + \theta$ for θ leaves the equation of *one* of the curves unaltered, say $F(r, \theta) = 0$, all the intersections are given in this way. For the other points would be given by—

$$f(r_1, \theta_1) = 0,\ F(r_2, \theta_2) = 0,\ r_2 = -r_1,\ \theta_2 = 180^\circ + \theta_1.$$
$$\therefore \text{by } f(r_1, \theta_1) = 0,\ F(-r_1, 180^\circ + \theta_1) = 0,$$
$$\therefore \text{by } f(r_1, \theta_1) = 0,\ F(r_1, \theta_1) = 0,$$

which gives the points already given by $f(r_1, \theta_1) = 0$, $F(r_2, \theta_2) = 0$, $r_2 = r_1$, $\theta_2 = \theta_1$.

3. Return to the example given in Section 1. Two points of intersection are given by $el' \cos\theta - e'l \sin\theta = l - l'$, (A), and therefore are real points if

$$e^2 l'^2 + e'^2 l^2 > (l - l')^2,$$

a condition which must be satisfied if the conics are parabolas or hyperbolas. The other two are given by $el' \cos\theta - e'l \sin\theta = -l - l'$, (B), and therefore are real points if

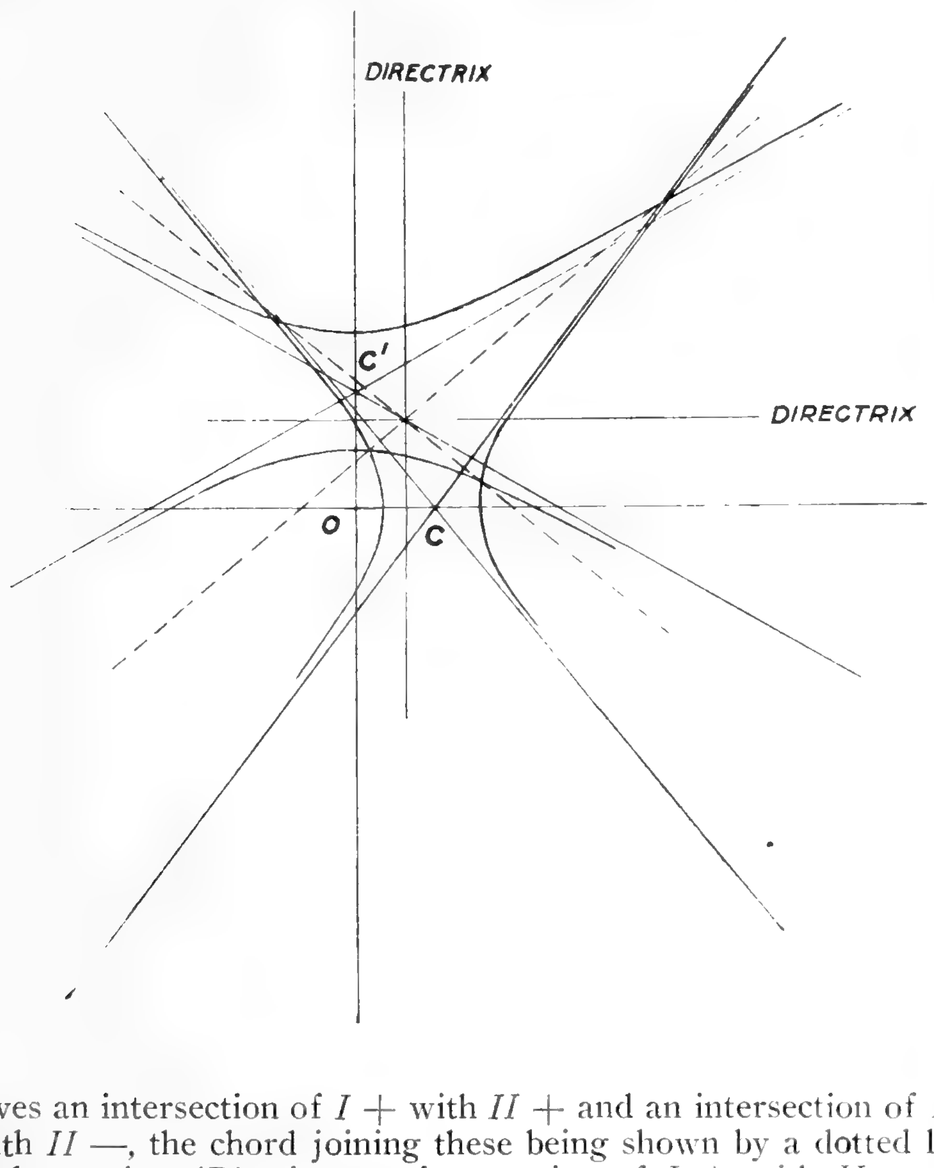
$$e^2 l'^2 + e'^2 l^2 > (l + l')^2,$$

a condition which cannot be satisfied if the conics are ellipses.

A distinction can be drawn between these pairs of points in the case of the intersection of two hyperbolas. If the first conic is traced by taking values of θ from 0° to 360°, for all

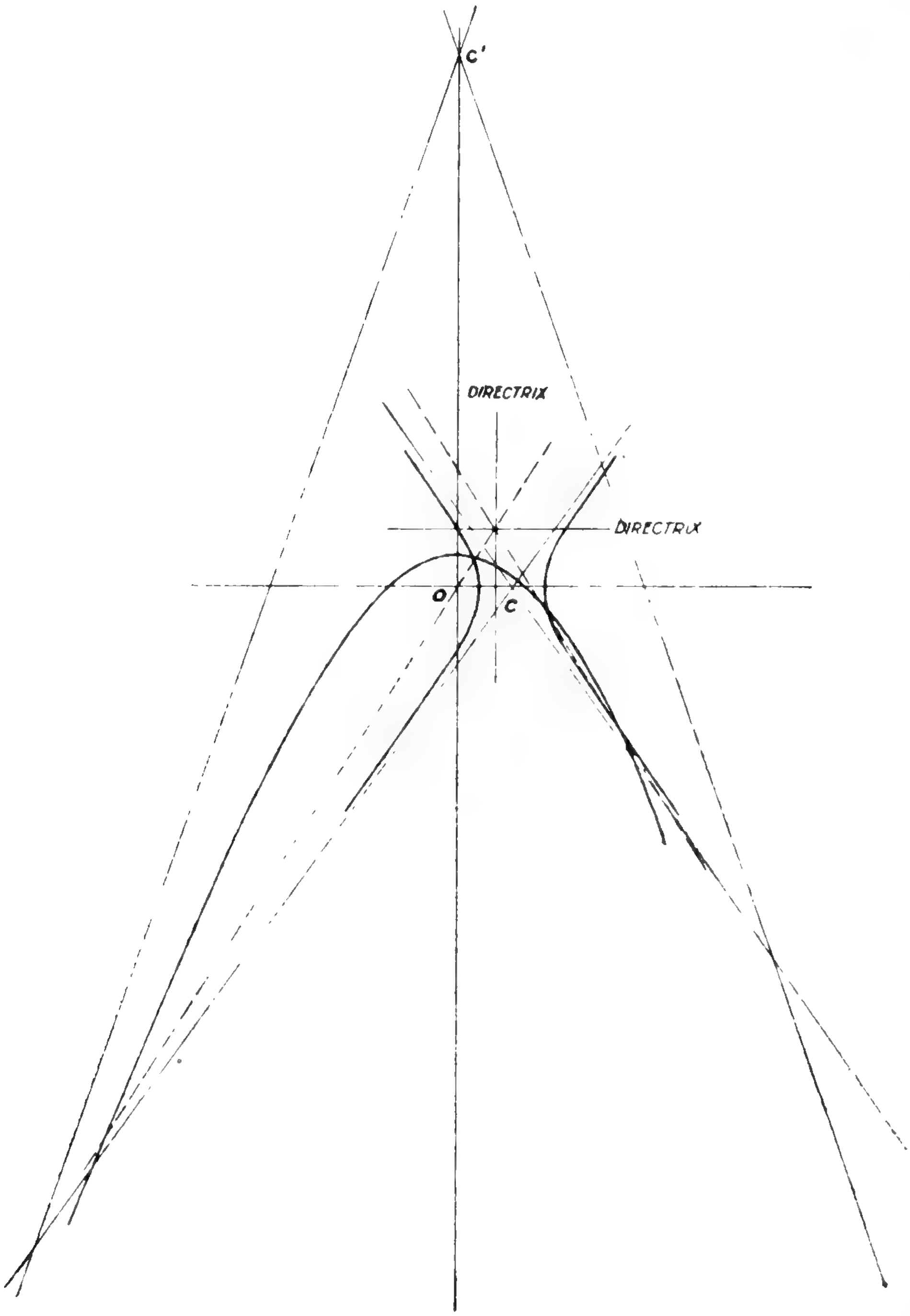
points on one branch r is positive, and for all on the other r is negative. Call these $I+$ and $I-$. $I+$ is the branch nearer to the common focus. Similarly call the branches of the second conic $II+$ and $II-$. The solutions of equation (A), taken between 0° and 360°, give the intersections of $I+$ with $II+$, and those of $I-$ with $II-$, while the solutions of equation (B), also taken between 0° and 360°, give the intersections of $I+$ with $II-$, and those of $I-$ with $II+$.

In Figure 1 two hyperbolas are drawn, $\frac{1}{2r} = 1 + \sqrt{3} \cos \theta$, $\frac{1}{r} = 1 + 2 \sin \theta$, intersecting in four points. Equation (A)



gives an intersection of $I+$ with $II+$ and an intersection of $I-$ with $II-$, the chord joining these being shown by a dotted line, and equation (B) gives an intersection of $I+$ with $II-$ and an intersection of $I-$ with $II+$, these again being joined by a dotted line.

In Figure 2, two hyperbolas are drawn, $\frac{1}{2r} = 1 + \sqrt{3}\cos\theta$, $\frac{1}{2r} = 1 + \frac{3}{2\sqrt{2}}\sin\theta$, intersecting in four points. Equation (A) here gives two intersections of $I+$ with $II+$, $II-$ not cutting



$I-$, and equation (B) gives two intersections of $I-$ with $II+$, $II-$ not cutting $I+$, the corresponding pairs being joined by dotted lines, as before. In the figure $II-$ is not drawn. Since here $l = l'$, the common chord through the intersections of $I+$

with II + goes through the common focus. In the figure I + is not produced to the lower point of intersection.

Note.—That the hyperbolas $\frac{l}{r} = 1 + e \cos \theta$, $\frac{l'}{r} = 1 + e' \sin \theta$ intersect in four points and each branch of the one cuts each branch of the other, the necessary condition (I give it without the working out) is independent of l and l', and is $e^2 e'^2 > e^2 + e'^2$ In Figure 1, $e^2 = 3$, $e'^2 = 4$, and the condition is satisfied, but in Figure 2, $e^2 = 3$, $8e'^2 = 9$, and the condition is not satisfied.

Fossil Man.—The British Museum has recently issued a guide to the fossil remains of man in its Geological and Palæontological Department. After explaining the significance of the various specimens comprising the exhibits, the author states the general conclusion that man, having a skeleton essentially identical with the existing one, lived in Western Europe long before the British Isles were separated from the mainland. His immediate predecessor, the Neanderthal or Mousterian man, more nearly approached the apes in the retreating forehead and other features. The still earlier Heidelberg man had a much more retreating bony chin, and the Piltdown man, probably older than the Heidelberg race, had both lower jaw and front teeth as nearly on the ape-pattern as was compatible with their working on a human skull of normal width: thus, the further that human remains are traced back in geological time, the more marks they retain of an ape-like ancestry.

Isotopes.—While the British Association was at Melbourne in August, 1914, Sir Ernest Rutherford, in opening a discussion on the structure of atoms and molecules, drew attention to the remarkable fact that radium B, with an atomic weight of 214, and lead, with an atomic weight of 207, were identical in respect of their chemical properties: chemically they were inseparable, and their gamma ray spectra were also identical, and he concluded that different varieties of lead exist, identical in every respect except in their atomic weights. Such varieties of an element have been designated "isotopes," and in the case of lead there appear to be several of them. Soddy, for instance, found that lead derived from thorite possessed a greater density and a higher atomic weight than common lead. It has recently been announced by Richards and Wadsworth* that lead derived from certain Australian radioactive minerals falls below ordinary lead both in atomic weight and in density; the density of ordinary lead being 11.337, while that of the Australian lead is 11.288.

* *Journ. Amer. Chem. Soc.* **38** [2].

THE PROFESSION OF PHARMACY: SUGGESTIONS FOR REFORM IN ITS MODE OF ATTAINMENT.

By Prof. J. A. Wilkinson, M.A., F.C.S.

The profession of pharmacy is one of the oldest known to mankind, but in spite of its antiquity it is yet, strangely enough, one of the few to which little attention has been given outside those engaged in its practice.

In many respects it has been regarded not in the manner of those of law and medicine, but more particularly, if one may so style it, as a professional trade—in other words, a particular phase of commercial activity requiring a professional passport at entrance. Being thus allied to the two branches, it often lacks the dignity of the one and the restless activity of the other. Many cases, however, are known in older countries where the cultivation of the one or other branch has led to great successes, in recent times especially, but in the majority of cases the very nature of the ordinary routine work prevents this consummation.

The lack of attention bestowed upon the profession has been reflected more particularly in South Africa by the utter disregard, until the last few years, of facilities for preparation for its passport, the examinations held periodically by the various Boards of Pharmacy, and even to-day these are to be found in only one or two localities.

Although the Union of the several Provinces of South Africa became law five years ago, the consolidation that was expected and hoped for in many respects has not yet been achieved. Provincial administration still rules in matters pharmaceutical, and the range of vision over this field is in consequence restricted to circumscribed geographical areas. With impending consolidation of interests reforms are possible, and as this is a measure with respect to Pharmacy, which will probably not now be long delayed, reference will be made in the following to a condition of affairs such as it is hoped may be brought about after this has been reached.

In a paper read some five years ago before the Pharmaceutical Society of the Transvaal,* an outline was given of the conditions as they existed in the four Provinces at that period, and as far as can be ascertained there has been little, if any, change since that period, probably owing to the expectations of legislation with each new session of Parliament.

When consolidation has been accomplished, uniformity in procedure is a necessary sequence, and the various steps may now be considered in order. Under present conditions not only

* *Transvaal Medical Journal* (1910) **8**, 171.

registration by the various Pharmacy Boards, but also indentures between the apprentice and his employers, are optional. The first step in reform is to make these compulsory by Act of Parliament, in order to ensure that the training subsequently undertaken shall be efficient. Before indentures are allowed to be taken out, registration with the Central Board should be required, and this should not be granted, until the preliminary examination has been passed. The latter should be of such a nature as to be easily accessible throughout the Union, such as the Matriculation or school examinations of the University of the Cape of Good Hope. No great difficulty is imposed in prescribing these examinations, owing to the fact that good schools now exist in every part of the Union. Of the tests mentioned, the Matriculation examination is to be preferred, as it is the usually accepted entrance to all other professions; but the difficulty, ofttimes experienced, of obtaining recruits has sometimes led to a relaxation of standard in this respect, which for the sake of the profession it is hoped will cease to obtain.

If registration be granted before the preliminary test has been successfully attained, a condition by no means rare hitherto, a division of labour is caused with its usual attendant evil consequences. Several cases of this kind have come under the author's notice, and the experiences prove conclusively the unwisdom of the permit.

Indentures once obtained, the apprentice commences his work in the pharmacy for such periods of time per day as may be arbitrarily fixed by his employer, consonant with the laws in force in the province or Union. Freed from the thraldom of school life, he forgets for the moment the path that lies before him, and even when he does allow himself to think of it, four years, to his inexperienced vision, spells an ocean of time as allowance for its preparation. His daily work is subject to considerable variations from the strictly commercial to the strictly pharmaceutical, and also, whether it be in town or country. More often than otherwise it is of such a nature that he does not derive that amount of assistance from it which is likely to be of any considerable value in preparing him for his final examination.

As at present constituted, there is only one test in this country, and at this all the subjects considered necessary for proficiency in professional practice have to be presented. It is in this respect more than in any other that reform is most desirable and necessary. In the paper already quoted, the desirability for this was mentioned, and subsequent experience has since abundantly confirmed the views there presented namely, the conduct of the examination in two stages, the first to be allowed after the lapse of one or two years of indentures, and the second at the end of the period. There is in most civi-

lised countries a fairly unanimous consensus of opinion on the subjects necessary to the practice of the profession; but on the other hand, a wide diversity on the standards necessary for proficiency. In the author's opinion, the latter are generally regulated by the means at hand which can be utilised for preparation. Canada and the United States possess fully equipped Colleges of Pharmacy, supported in most instances by the State, and qualification can only be obtained by graduation from one of these colleges.

In England the Pharmaceutical Society sets aside much of its building in Bloomsbury Square for the purposes of a training college for students, who generally attend for two years, but attendance at this particular institution is not compulsory. The result has been the growth in large numbers of other institutions, which provide almost any kind of fare demanded by the would-be minor or major candidate. There is no doubt that many of these private schools fulfil a want, but, on the other hand, even the mildest critic cannot escape from the feeling that the majority of them are of the nature of cram schools, desirous of obtaining passes for advertisement sake. In this connection a comparison of the number of candidates passed by these institutions per annum with the total number of successes is instructive.

In Melbourne, Australia, there is a College of Pharmacy, and at Sydney the University has a department specially devoted to this work. In South Africa we have colleges and technical schools in each Province, but, as far as can be ascertained, only the Natal and Transvaal Provinces attempt to provide specially for this work. At Capetown no special facilities are granted by any of the leading educational institutions, a somewhat remarkable fact, considering that the size of the town should connote as large a number of candidates as could be found in any other portion of the Union.

On the basis of the suggestions for reform made above, it would be interesting to examine how far it is possible to make use of the existing means for education, which are so amply provided in every Province of the Union. Happily there is in the Transvaal and Cape Provinces more or less complete unanimity regarding the desirability of raising the standard of the preliminary examination. Whether the Matriculation will be eventually adopted officially is a moot point, but if it were, there can be little doubt of the beneficial effect it would exert on the future progress of pharmacy. Further, this examination unlocks the entrance door of the various University Colleges within the Union, a factor of some importance in the proposals made later. Registration as an apprentice to the profession follows, but according to the plan adopted by the student, he should be allowed to register himself in two ways, either as a

student at a University College or approved institution of similar rank, or to a practising pharmacist. In this the assumption is made that the suggested reforms have been accomplished and the examinations conducted in two stages. Indeed, the subjects necessary for qualification readily lend themselves to such a division. In the first examination the fundamentals of Chemistry, both Inorganic and Organic, Physics, and Botany would be taken, and in the second the applied portions of the subject, including Materia Medica, Pharmacy and Dispensing, Toxicology, etc.

If a student elected to attend a University College, he should be able to complete the courses and present himself for the first examination at the end of his first year, and this course of action should not only be allowed, but encouraged. In fact, it would not be a disadvantage entirely if this year at college were allowed to rank as equivalent to the ordinary first two years' indentures of a pharmacy.

In the examination given at the end of this period, special stress should be laid upon proficiency in practical work in every branch, since courses in this form now an integral portion of the instruction given. Should it be impossible for this course to be pursued, it is open to the student to apprentice himself to a practising pharmacist in the ordinary way. In order to prepare himself, however, for the qualifying tests, he is compelled to seek the aid of his employer or other private tutor, or of evening class instruction in public institutions. Of the latter there are few which offer special courses for this work, probably owing to the fact that the number of candidates at any one time is, comparatively speaking, small. On the other hand, it should be remembered that the call for good apprentices has always existed in this country, and has never yet been fully met. Importation still continues, in spite of the fact that in England the demand exceeds the supply, and this has greatly increased since the outbreak of the war last August, owing to the calls made for service in the cause of the sick and wounded. It is, however, a matter of experience that the provision of special facilities soon brings its own reward. On the one hand the classes grow both in quantity and quality, and on the other hand the presence in the pharmacies of apprentices eager to qualify soon creates an atmosphere in which the unqualified intruder finds no place. The present system of crowding all the subjects into one test is a serious deterrent, owing to the fact that the number is too great, and would be even for the college student, assuming a high efficiency throughout, and also for the fact that the average apprentice finds it almost an impossibility to keep all the subjects going at the same time at concert pitch; and so long as this lasts, a lower standard of

efficiency than is desirable in the interests of the profession and the country is of necessity attained.

But even with the subdivision proposed, it is a tax upon the student after a day's work in the pharmacy to be required to prepare himself for a strenuous examination, unless special means of assistance are at hand; hence the necessity for the provision of such courses by public institutions, especially those with departments for evening instruction. This is even more particularly the case in this country, on account of the dearth of private instruction of a suitable character. Lack of these facilities, public and private, has caused much migration to England in the past. If the would-be candidate should be serving his indentures at a country pharmacy, he has, generally speaking, but little hope of assistance other than that which his employer is willing to render, since at present there is no scheme in force by which he can effect a temporary exchange of posts in order that he may bring himself within reach of such facilities as do exist. In Australia such exchanges are effected through the agency of the local Pharmaceutical Societies, an example which might be followed with advantage in this country.

In the subjects of the final examination, which are of a more strictly professional nature, it is even more difficult to find the necessary instruction other than that which is learnt in the ordinary routine work of the pharmacy. Pharmaceutical laboratories, such as are to be found in the College of Pharmacy referred to above, are practically non-existent in this country, and in consequence the study of practical pharmacy, except on a small scale, is denied. This condition may be expected in a comparatively new country like this, but there are many who think that a necessity of this nature should soon be forthcoming. The practical utility of such a laboratory would soon prove itself in competent hands in many ways, not least in the investigations of the toxic principles of South African plants, most of which have hitherto been carried out in Europe. The Poor-Law Commission considered the question of the establishment of public dispensaries, and the utilisation of these as a training school for future pharmacists would be attended with great benefits.

The mere existence of examinations accompanied by a want of means for passing them is not sufficient attraction, but rather the opposite, and until this state of affairs is remedied, migration to England is sure to continue. In some respects a year's study in England is regarded by many as a *Wanderjahr*; but there is another reason of a more important nature which at the present moment impels many, who otherwise might deem it inexpedient, to pursue this course.

The certificates granted by the English authorities are valid throughout the Empire, whereas at the moment those granted

by each of the four Provinces of the Union are invalid outside the boundaries of the Province which granted them. The latter anomaly will disappear upon consolidation, but reciprocity with England and other portions of the Empire—in other words, the right to practise as a pharmacist in any part of the Empire on the basis of a certificate in South Africa—is a question which will be somewhat difficult to solve. The true solution will lie in the nature of the examination and the tests imposed therein. The standards to be aimed at must be higher than those prevailing elsewhere, and, as has been shown above, this can be achieved primarily by a subdivision which must of necessity connote an increase in the proficiency required of candidates. In this connection it is worthy of mention that the number of pharmaceutical candidates in England who proceed to University degrees or diplomas of recognised Scientific Associations is increasing. In the Colonies, on the other hand, the final examination is in most cases looked upon as the consummation of attachment to things scientific.

During the last few years the Australian Pharmacy Boards have interested themselves in the question of reciprocity with England, and as a consequence, after much labour, the basis of the principles upon which reciprocity could be carried out has been arranged. On March 6th, 1912, the Privy Council approved the scheme "providing for the registration, upon payment of the prescribed fee, as pharmaceutical chemists, or chemists and druggists under the Pharmacy Acts 1852 and 1862, without examination of any persons holding Colonial Diplomas."

The value of the reciprocal recognition of diplomas lies not so much in the remission of the work necessary to pass fresh examinations for qualification in England or the Colonies, as the case may be, as in the advantages which are made possible to Colonial practitioners in a *Wanderjahr*, and this point of view should be kept in mind more particularly, should reciprocity be obtainable on mere application. It is but seldom that a Colonial pharmacist returns to practise permanently in Great Britain, and hence to the great majority reciprocity has little or no value other than that of sentiment. In the opportunity presented, however, for keeping abreast of advances in pharmaceutical knowledge it has a value commensurate with the uses to which it can be put, and it cannot be denied that these are great and manifold. In this sense it is a privilege worth great efforts to obtain.

The present time is noteworthy in the annals of pharmacy owing to the appearance of a new edition of the British Pharmacopœia, upon which is based eventually all ideas of educational advancement in this profession, and which is the official record of progress made. The adoption of this edition was recently made compulsory by law in the Transvaal. From the points of view taken above, there is one change which will

be welcomed by all scientific men, namely, the adoption for the first time throughout of the metric system. Another impression, which even the casual observer cannot escape, is the necessity for a more intensive study during the earlier years of preparation for the profession of the subject of organic chemistry, which now plays so conspicuous a part in the modern drug world. Synthetic organic preparations have been common articles of commerce for many years now, and the tendency is for their number to increase. On this ground alone the necessity for a greater attention to this subject is of importance, but the sections relating to commoner organic substances, such as the fixed and essential oils, acids, etc., have been much amplified from a more strictly scientific point of view, rendering a knowledge of the subject more needful than was formerly the case. A large number of other changes have been made in the present issue of this well-known work, but they have little bearing on the subject at issue.

In conclusion, the author ventures to hope that the suggestions herein presented may be found worthy of consideration when the time arrives for the union of the Boards now representing pharmacy in the four Provinces.

Problems of Living Matter.—In the Guthrie lecture, delivered before the Physical Society (London) on the 28th January, 1916, Mr. W. B. Hardy, M.A., Sec.R.S., dealt with a number of interesting phenomena observed in the study of living matter and with the problems raised thereby. The activities of the simplest organisms are, he said, as simple at first sight as their structure; but the appearance of simplicity is only an example of the characteristic of living matter, the adaptation of means to end. Many of the long-accepted theories of the structure of living organisms were due wholly to the method of killing the organism and preparing it for examination, and exactly similar structures could be obtained in pieces of gelatine if treated in the same way. Interesting results were observed in connection with the study of vitamines and their effects: rats fed on synthetically prepared milk lost weight and died, but when to this artificial milk as little as 2 per cent. of ordinary milk was added, the growth rapidly became normal. On the other hand, in mice, inoculated with a rapidly growing sarcoma, and fed on a chemically prepared diet, the progress of the cancer was relatively slow: a mouse after 52 days of artificial diet showed a tumour only 4 mm. in diameter. It was then put on normal diet, and in 30 days the tumour was nearly as large as the mouse itself.

THE FAULT SYSTEMS IN THE SOUTH OF SOUTH AFRICA.

By Professor Ernest H. L. Schwarz, A.R.C.S., F.G.S.

If it were asked in what particulars the work of pioneers of South African geology like Andrew Bain and E. J. Dunn differed from that done by the Geological Surveys, it might be said that, apart from the greater detail of the latter, the systematic survey takes more fully into consideration the question of faults. It is very easy to mark a fault on the geological map; in fact, it is a general rule in the field that when in difficulty put in a fault, and it can be said that the full recognition and proper use of this principle were first applied in South Africa by the Geological Survey of Cape Colony, established in 1896. The fault system has now been more or less completely mapped in the Cape Province, and the fractures occurring in the various localities have been described, but so far there has been no general review of the faults taken by themselves, nor of the interrelationship between faults of various periods and between the faults and the fold system.

A few general remarks are necessary in introducing the subject in order to make clear in what sense we are using the various terms employed. In the first place, a fault is here understood to be a normal fault caused by a sinking of a part of the earth's crust along a certain plane; it is due to a tangential stretching of the earth's crust, whereby a block falls down, and it is the direct opposite of a fold, which is produced by tangential pressure resulting in the squeezing upwards of a ridge. A fold may break along the axis, and one portion may be pushed over the other, but such reversed faults are more properly called thrusts, and have nothing in common with the normal tension fault.

In the second place, a fault being the result of a sinking of the ground, somewhere in the neighbourhood of any given fault there must be another fault; that is to say, if we come across a fault running east and west with a down-throw to the south, somewhere to the south of the line of outcrop, we must find a second fault with down-throw to the north. The simplest case is in the Great Rift Valley of Central Africa, in which one looks across from the one plateau to the other, and in between there is a strip of country let down vertically several thousand feet, between two faults, yet having all the surface-features the same as those on the plateau of which it once formed a part. Now, this second fault need not necessarily be a direct break, which is the essential feature of a fault. Supposing the strip of earth's crust sinks along a certain line, it may happen that instead of breaking away on the far side, the strip may simply bend without breaking, hingeing, as it were, on a line

which, with a greater tension, would become a second fault. Such a fold, having all the effect of a fault in that it lets down a strip of the earth's crust, is called a monocline, because, unlike other folds, it has an inclination in one direction only. What I want to emphasize here is the fact, often lost sight of in practice, that a fault must have a companion, or counter-fault, or a monocline in the near neighbourhood.

If the earth is pulled apart, and two slips are faulted down with a zone between them that remains unaffected, this zone will become relatively higher than the rest; it will constitute a block-mountain, or horst. This peculiar structure is common in the plateaux of Utah and Colorado, and the gridiron country of von Richthopen in China, and is exemplified by the fault-block of Madagascar, which has a fault in the east and a monocline in the west. In the area with which we are dealing, there are no examples of block-mountains.

In the third place, faults have a limited horizontal extension, which is self-evident, as otherwise they would go right round the world. The way a fault dies away, however, is not so obvious. At Worcester, for instance, we find the Ecca beds brought down on a level with the Malmesbury clay slates; at Robertson the Dwyka Conglomerate, underlying the Ecca, touches the Malmesbury beds; further east, the Witteberg underlying the Dwyka Conglomerate, and still further east, the Bokkeveld underlying the Witteberg, and then the Table Mountain Sandstone underlying the Bokkeveld, in turn come level with the Malmesbury Clay Slates; finally, at Swellendam the fault dies out with the Table Mountain Sandstone on the south of the line of fault-arching over the Malmesbury beds, and joining the Table Mountain Sandstone on the north of the line. The downthrow at Worcester is two miles vertical on the south side, and this is reduced gradually in the east to nothing. It will be found in the sequel that the post-Cretaceous faults have this property of disappearing very markedly developed. A fault in this system, after beginning quite abruptly along a certain line, lets down the faulted area to its maximum within a short distance of its commencement, then as abruptly peters out, leaving the ground quite unaffected for a certain distance; then the fault appears again, the same downthrow occurs, and the fault again peters out, and so on repeatedly. This may be, perhaps, better illustrated by taking the Great Rift Valley again; then the floor is sometimes very deep with great lakes, such as Tanganyika, in the bottom, and further on the bottom rises, and the rift apparently dies out, only to recommence after an interval.

The relationship between faults and folds is never rigidly uniform; generally we can state the relationship in terms of time and space. For the first, we may say that a fault usually follows a fold. When pressure accumulates in the earth's crust, and a folded mountain range is produced, the resulting fabric is usually greater than the pressure warranted, and as a

result a tension ensues, causing the faults. There may be cautious mountain ranges where the folding is just equal to what the pressure demanded, but I do not know of them. Nature, even in her grander works, shows a generous recklessness, and this makes our mountains more interesting than had they been built in a spirit of hard calculation. Faults, on the other hand, may occur without any pressure preceding or following them. The whole of Africa, leaving out the Atlas Mountains on the north-west, together with the peninsula of India, and in all probability the Indian Ocean between them, is a faulted block of the earth's crust. It is true it is bounded on the north by the great folds of the Alps-Himalaya System, which are contemporaneous with the post-Cretaceous faults, and so in a way we may say that the faults of Africa have some relationship with folds. In this matter, however, the area is so vast that no one has yet been able to grasp the general outlines of the case. To me it has seemed as if the faulting, fracturing, or smashing up of the Indo-African Continent resulted in a spurting up of the earth's crust in a ridge round the edge, this ridge being now represented by the Alps, Himalayas, and Burmese Mountains, with the Aleutian chain, the Rocky Mountains, and the Andes as an outer and lesser rim. Such a smashing up could only have been effected by a blow from the outside, which could be brought about by the infalling of a giant meteorite on to the earth. A meteorite 1,000 miles in diameter, or, say, half the diameter of the moon, could have fallen into the Indian Ocean between the Peninsula of India and Somaliland, north of the Seychelles, and had it so fallen in the period between the Cretaceous and Eocene periods, it would have produced all the fracturing observed.

As regards the ridging up of the earth round the fractured portion, I have endeavoured to reproduce the conditions experimentally by mounting a large globe of modelling clay on a potter's wheel, spinning this round at a great rate, and then shooting on to it a ball of clay of the same relative dimensions to the large globe as a meteorite of a 1,000 miles diameter would have to the whole earth, that is to say, the projectile was one-eighth of the diameter of the globe. I obtained a splintered area with a ridge round it, where the ball of clay entered the revolving globe, but the effects were not sufficiently clear for demonstration purposes. The experiment failed because of the want of tenacity of the modelling clay when spun round so rapidly, for the large globe tore away from its axis. It is necessary to have a more or less plastic substance, as very large objects as the earth as a whole, and even a meteorite half the diameter of the moon, act as plastic bodies owing to the want of cohesion due to their bulk. I have not yet succeeded in finding a suitable medium. The whole experiment was designed to show more than the fracturing and ridging of the globe. The area struck by the infalling body became dented; I had

also hoped that this dent would gradually heal itself by the forces acting on the plastic medium due to the rapid revolution. In the case of the earth, had such a meteorite fallen, then the dent would have been a seething cauldron of molten rock due to the heat caused by the impact. This would crust over by dissipation of heat into space, and a region of tremendous volcanism would result, such as we know existed in the North Atlantic between the north of Ireland and Iceland, extending to Greenland. It is, however, not within the scope of the present paper to follow out this particular line of reasoning. I have mentioned the experiment to show how possibly faults may precede folds, although this fact is not yet established by direct observation.

In regard to space, faults, generally speaking, are deep-seated, and folds are superficial. In crossing folds and faults the fold would ride over the fault. There are no good instances in this country, but what is meant can be illustrated by the rift valley in which the upper Rhine Valley lies. The great fault-trough of the Red Sea is followed, after an interruption in the Sinai region and in the Mediterranean, where surface features are hidden by the water, by the fault-trough of the Adriatic. North of this there is the great barrier of the Alps, and yet to the north the fault-trough, much diminished it is true, appears along the Rhine. The fault-trough has dived, as it were, beneath the Alps. Another branch of the Red Sea trough, which runs up the Gulf of Akaba, forms the walls of the Dead Sea and the Valley of the Jordan, and ends at Lake Tiberias. Here there are the feeble outposts of the fold-system of Eurasia, which have proved sufficient to stop the further progress of the fault. In this latter case, then, the earth-crack has not been sufficiently powerful to overcome the barrier of the fold.

So much for the bearing of faults on the country through which they pass. In regard to the details exhibited by faults, we have many very excellent and characteristic types in South Africa. In typical faults the break is a clean-cut fracture; one side sinks down, the other remains stationary. Such faults may be exemplified by the great Worcester-Swellendam fault. The rocks there were unable to stand the tension, and simply parted. No signs of friction along the fault plane are noticeable. This would have happened had there been any pressure of the one side against the other while the movement was in progress; or if the side that was sinking, instead of doing it vertically, became tilted forwards by the hinge-like movement of the strip of ground on the counter side of the fault. On the other hand, there was not an excess of tension causing a gap between the two sides of the fault. Occasionally one comes across, in South Africa, a fault with an opening between the two sides; such a case occurs in the district of Matatiele, where a dyke of dolerite is inserted along the plane of the fault. Underground faults are

frequently represented by fissures, which have subsequently become filled in with vein-material and now form ore-veins. The larva-filled fault-fissure of the Zuurberg is a special case, which I shall refer to separately.

The Worcester-Swellendam fault is also interesting in illustrating the effect of material of different toughness in responding to the tearing forces developed along the fault. As long as the fault traverses normal sediments, slates and sandstones, the fault runs more or less in a straight course, but at Robertson there is a big dome of granite which has proved too massive for the fault to tear through, and consequently the line runs round this obstruction, showing on the west side an interesting splintering in the rocks of the down-throw side. The effect of the Robertson granite is that of a knot in a piece of plank that is being split for firewood.

In contrast to these clean-cut faults, which show no trace on the surface except in the different geological formations which require a practised eye to notice, we have the Baviaans Kloof faults. Here the width of the strip let down is very narrow, a couple of miles or so, and in some cases less. Most of the faults have their counter fault in the form of a monocline. It is obvious, therefore, if a great block of the earth's crust is bent downwards in the line of the break, the top end of the block will butt against the opposing side of the fault-plane, and the lower portion will leave an open space. To illustrate what I mean, place a thick book edgewise against the wall and then bent it downwards; the top cover will scrape the wall, and the lower cover will not be in contact with it. The consequence of this movement is that along the fault-planes of Baviaans Kloof we find immense zones of broken-up rock, where the earth-block has scraped along the fault-plane.

In the Zuurberg, at Mimosa, on the Port Elizabeth railway-line, the result of a similar tilting of the sinking block is shown in a band of lava which occupies the fault-plane together with two small volcanic necks. When the block sank, the lower portion separated from the stationary rocks on the north side, and an open space resulted. Now, in the earth's crust no spaces can long remain open. Small fissures are filled in by the deposit of minerals, which constitute the ore-veins; larger ones are gradually closed by the operations of the law of viscid substances, for the earth's crust is, in spite of the apparent hardness of the rocks of the surface, perfectly plastic to long-continued stresses. If, however, there is molten material ready to hand, the molten rock rushes up the fissure, and either solidifies as a dyke, or if the fissure is sufficiently near the surface of the earth, the up-rushing molten material forces an opening, and a volcano results. I am still inclined to think that the frictional heat caused by the grinding of the two segments of the earth's crust against each other was the determining cause of the Mimosa volcanoes, not, perhaps, causing the entire heat requisite

to melt the rocks right away from the cold, solid state to the molten one, but yielding sufficient additional heat to the underlying rocks already under great heat, and pressure to make them pass from the solid to the liquid condition. The gap formed underground by the sinking block would act as a conduit for this molten material, and make for it an easy passage to the surface. This crushing, or brecciation, of the rock along the fault-planes may occur in faults in which the block on one side simply slides down along the fault-plane, but as far as my field knowledge carries me, I do not think that it is at all common; the great faults that I have studied are wonderfully free of any signs of disturbance along the fault-planes. I am inclined to think, therefore, that where crush conglomerates occur, it will usually be found that there has been a tilting of one side of the fault. Such conglomerates are found, for instance, in the Table Mountain Sandstone area of Berg River Hoek, near Paarl, and in the western Head at Knysna, and also constituting a sort of banket in the Tebekwe Mine, Selukwe, in Rhodesia. In the Baviaans Kloof the breccia is uncemented, each fragment lying loose among its neighbours, but in the Berg River Hoek and Tebekwe Mine the blocks have been re-cemented by deposit of silica from circulating water, and an intensely hard rock results. The originally angular blocks in the zone of crushing in the Tebekwe Mine and in the Knysna Head have been rounded by repeated up and down movement in the line of fault, causing the loose blocks to be rolled, so that what was at one time a breccia has now become a conglomerate.

Fault-planes from their nature are eminently suited for the percolation of water, hence we often find springs rising in the outcrops of faults, as in the case of the Cold Spring, near Grahamstown. On the other hand, this very fact of the break in the rocks tending to form a water-leading carries with it the consequence that prolonged percolation causes the choking of the fissure by means of mineral deposit, and hence some fault-planes are more solid and impervious to water than the rocks adjoining. The question arose in the Berg River Hoek whether it would be safe to build a dam wall across a particular fault plane; on investigation, it was found that where the crushing along the fault occurred, the rock was so firmly cemented that it was far more dense than the unaffected rock in the neighbourhood.

In the more superficial positions of the earth's crust the movements that are continually occurring in it tend to tear and rend it, so that underground fissures are formed. In this country, where the rocks for the most part are impervious, these fissures are practically the only source of deep-seated underground water. They act practically as an artesian system in that the water is conducted from a higher level to a lower, and may be turned up to the surface by a bar of hard rock, such as

a dyke of dolerite or a fold of quartzite. It is, unfortunately, impossible in most cases to locate these underground fissures from the surface, so that deep boring in this country is always a matter of great risk. In true artesian areas the pervious strata carrying the water lie more or less horizontally, and the bore must strike them if carried deep enough. Here, where we have to deal with fissures, it is quite another matter; from the fact that fissures are for the most part vertical, a bore-hole may be put down within a foot or two of quite a large fissure carrying water, but the bore-hole may be dry.

In the deeper portions of the earth's crust the tearing action also occurs, but the pressure and plasticity of the rocks keep the fissures from opening, and we have potential faults or fissures. The strain along these lines is, however, sufficient to allow the passage of mineralising solutions, which find the strained material more easy of penetration than the surrounding rock. Some extremely interesting examples of this occur in the gneiss zone in the rock-shaft of the Kimberley Mine, where the granitic minerals, quartz, felspar, and mica have been introduced along the strain-zones in solution, and have grown as separate crystals in the hornblende schist, which still forms the matrix. In this way shadowy dykes are formed, made up half of the granitic minerals and half of the original schist.

The two fault-systems with which we have to deal are those of the post-Karroo and post-Cretaceous movements. The first followed the great folds, which resulted in the coastal mountains of Cape Colony, and broke through all rocks up to and including the lower Karroo. The second group is more recent, and is of quite a different nature to the first, and to this system are due the pit-faults in which we find the Cretaceous rocks of South Africa. The first system produces a series of slices of the earth's crust, each inclined inwards towards the interior of the land, and ending abruptly on the sea-ward side in a fault; this peculiar structure occurs in its greatest development in the north-west of the Iberian Peninsula, and was called by Suess the imbricate structure, because it resembled in some way the manner in which the scales on a lizard's back follow each other. It must be understood, however, that the earth's crust scales do not tuck in under each other as in the reptilian scales, but only incline towards each other in the same way; where the two scales meet there is the break or fault. The second series of faults, because they always run in pairs and let down strips of earth's crust between them, may be called the Trough Fault System.

The Imbricate System of Faults.

It is presumed that the order of sequence of the strata or layers of rock in Cape Colony is known; at the base there are the Malmesbury beds with intruded granite, overlain unconfor-

mably by the Cape and Karroo formations. The thicknesses of these last in the area under consideration are:—

Ecca Series	1,000 feet	(the top is not preserved)
Dwyka	1,000 feet.	
Witteberg Series	1,500 feet.	
Bokkeveld Series	2,500 feet.	
Table Mountain Series	5,000 feet.	
Giving a total of	11,000 feet,	or a little more than two miles.

To illustrate at the outset what is meant by the imbricate structure, a traverse from the Bredasdorp coast to Prince Albert will exhibit the following succession of strata.

1st Scale.—At Bredasdorp, near the coast, we have Malmesbury beds, then comes Table Mountain Sandstone in the hills overlying these; then towards Caledon comes the overlying Bokkeveld, and at Caledon Mountain a fault.

2nd Scale.—From Caledon Mountain, which consists of Table Mountain Sandstone, we go northwards over the overlying Bokkeveld beds, which are overlain by Witteberg beds near Genadendal, then comes a fault.

3rd Scale.—From the Genadendal fault northwards we find the Zonder Einde Mountains made of Table Mountain Sandstone; at their base lies the overlying Bokkeveld beds, dipping north under the Witteberg; this dips under the Dwyka, and the Dwyka under the Ecca beds near Robertson; then comes the great Worcester-Swellendam fault.

4th Scale.—Shifting our line now a little to the east. To begin with, there are the Malmesbury beds under the Table Mountain Sandstone of the Langeberg; above the latter come the Bokkeveld beds of the Ladismith Karroo, brought up against a fault at Calitzdorp.

5th Scale.—In the Cango we have Malmesbury beds again overlain by the Table Mountain Sandstone of the Zwartberg Mountains; these are succeeded on the north by a valley of the overlying Bokkeveld beds; these underlie the Witteberg in the north, the Witteberg underlies the Dwyka, the Dwyka the Ecca, and the Ecca the Beaufort beds; so we arrive in the Karroo, where the faulting stops. Leaving out the surface features and the folding, we have practically five earth blocks made of the Cape and Karroo strata, all of them inclined towards the north, and cut off by a fault in the south.

In the division of Ceres the same imbricate structure is exhibited only on a smaller scale, and the tearing forces have not been sufficient to cause definite breaks, so that the faults are represented by monoclines. To the north and east of the Warm

Bokkeveld, the valley in which the village of Ceres lies, there is a great stretch of yellow quartzites of the Witteberg Series. It is in these Witteberg Mountains that the monoclines are seen to the best advantage. North of the village of Ceres there is the great wall of the escarpment of the Waagenboom's Mountain, consisting of a cliff showing the layers of the Witteberg beds; on top there is a plateau of the topmost of the quartzite layers, dipping northwards at an angle of some 15°. If these layers continued to dip northwards at this angle the overlying Dwyka would soon be found covering them, but before this can happen there is an abrupt monocline bringing up a strip of Witteberg rocks to the same level as the far end of the first block. This second dips at the same angle, and in turn is brought up against a monocline. Some 30 or 40 of these monoclines can be found in this area, all extending parallel to each other in an E.S.E. direction; once only, to the north of Ceres village, the Dwyka beds are brought down to the level of the surface of the country, and at the northern end of the inclined block, instead of the usual monocline, there is a fault. Of course, the Dwyka conglomerate at one time covered all this area, but owing to its more argillaceous character, it has yielded more readily to the action of denudation, and all traces of it have been removed from the elevated portions of these mountains; the Witteberg quartzites, therefore, which are very hard near the top, and resist weathering, are, as it were, cleaned of their covering, and show in naked outline this remarkable system of monoclines. Between the dip-slopes and the monoclines there are naturally valleys which, in this area, have also had the overlying Dwyka beds cleaned off them by denudation, so that we find here the rare case of rivers running in valleys formed for them by the folding of the rocks. In the area north of Ceres (and the same is seen round Constable, on the main line from the Cape to the North), the larger rivers cut right through everything irrespective of the hardness of the rock or the presence of folds, but the smaller tributaries, having less erosive power, lie in these structural valleys, and may be seen in a large scale-map all running in parallel courses and at nearly equal distances apart.

The faults belonging to the system under discussion run more or less parallel to the folds. The folds are arranged in two great lines east and west, north and south; the angle where they meet is a *schaarung* or knot lying actually in and around the Warm Bokkeveld; from here the trend lines of the folds stream out in a south-westerly direction towards Cape-Town. Had the two systems of folds been of equal value, the resulting angle-folds should have formed in a direction exactly bisecting the angle at which the two systems met—that is to say, with the two main folds running east and west and north and south, the folds starting from the angle ought to run exactly south-west. In our case of the Western Province, however, the east and west lines of mountains, including the Zonder Einde, Lange-

berg, and Zwartberg ranges, is the dominant, and the north and south line is the subordinate fold-system, this latter line including the Great Winter Hoek, the Witzenberg, the Cold Bokkeveld mountains, and the Cedarbergen. A glance at the map will show that the east and west mountains cover a far broader belt, and are buttressed by a number of parallel subsidiary ranges, such as Touws Berg, Warm Water Berg, and so on. For this reason the folds streaming from the junction of the two main lines trend in a S.S.W. line instead of a S.W. one, the northern end of them being, as it were, pushed over to the west. There are some fractures accompaying these folds in parallel position, but the more important ones are at right angles to this direction. We have already dealt with the Ceres monoclines, which have this direction, namely, E.S.E. (which is at right angles to S.S.W.), but the greatest of all the South African faults belongs to this set and lies in this direction, and is the great Worcester-Swellendam fault. The Worcester-Swellendam fault, then, may be defined as a cross fault in the area of *schaarung* or junction of the two main mountain ranges of Cape Colony. It is as if the two ranges, the N.S. and E.W. mountains, in joining issue at the angle, raised the portion of the earth's crust above the bearing capacity of the span, and consequently the outside corner was broken off and sank. The inside of the bend was also rucked up above its natural level and also collapsed, producing the monoclines of the north and east of the Warm Bokkeveld.

The Worcester-Swellendam fault has a maximum throw of two to two and a half miles in the central portion between Worcester and Robertson. Here the Ecca lies against the Malmesbury beds, with no surface indications at all that there has been this great disturbance; one can stand with one foot on the Malmesbury and the other on the Ecca, with the fault between. It was only when I found impressions of the leaves of the Karroo fern *Gangamopteris* in the shales which, up to then, had been regarded as Malmesbury beds, that the nature of this great structural feature became evident. Great as the throw of this fault is, it is by no means exceptional; on the east coast of India and under the Himalayas in Assam similar faults occur, letting down tongues of what are actually Karroo beds, though they are called in India Gondwana beds, into and against the gneiss and granite which takes the place of the Malmesbury beds. The Gondwana series in India is somewhat different from, although it is contemporaneous with, our Karroo beds, and contains the same fossils. The main difference is that these Indian equivalents contain vast quantities of coal, so that, as the extent of the coalfields depends on the faults, the latter have been very thoroughly studied. The Indian faults reach a maximum of 20,000 feet downthrow, or almost double that of the Worcester-Swellendam fault.

The Cango fault in Oudtshoorn is a direct east and west fault under the Zwartberg Mountains. To understand the somewhat complicated relationship between the folds of the Zwartberg and the fault, we can have recourse to a homely illustration. The southern fold of the Zwartberg is an anticline pitching to the west near Calitzdorp, and pitching to the east near Meiring's Poort. Such a fold may be represented by an upturned boat. Imagine the boat to be full of sand now forming a mound covered by the boat. On the south side, halfway between the keel and the outer edge, make a longitudinal cut and drop the outer portion; this cut represents the Cango fault. Now cut away all the central portion of the keel between the bows and the stern. The underlying sand will appear; scoop a large quantity of this away, and the boarding of the boat still remaining will consist of the bows and the stern united on the north side by what is left of the side of the boat. This boarding represents the Table Mountain sandstone of the Zwartberg, and the sand represents the underlying Malmesbury beds of the Cango. Actually the line of the fault is covered by cretaceous deposits, for the Cango fault, after slicing off the older rocks in the manner just indicated, became a line of renewed movement, this time bringing down the cretaceous beds with it. Suess has called a fold that is developed on the lines of a previous fold which has died out a posthumous fold. I do not think, however, the term posthumous is suitable for the case of a fault developing on the line of an old fracture, but the recognition that a fault-plane can be the seat of two movements separated by considerable periods of time is not always borne in mind. The want of it has led to considerable confusion, especially along the Worcester-Swellendam fault, where the same renewed movement took place in the cretaceous fault-pit lying to the east of the town of Robertson.

The faults of the N.S. line of mountains are not of anything like the importance of those in the E.W. direction. The faults occur, but while they throw the ground in the sense of the imbricate structure, since they only bring up Bokkeveld beds against Table Mountain sandstone, they can be looked on as ordinary accompaniments of folds.

The Trough System of Faults.

Supposing one had a wheel with some square pegs let into the rim, and this wheel were run over some soft substance like clay or dough, the pegs would make dents at intervals, separated by undisturbed clay or dough. The dents would be in a definite line, and would belong to the same series. So the fault-pits of this system of fractures, although they are separated by undisturbed tracts of country, may be said to belong to certain linear series. The wheel has run in three parallel courses over the coastal districts of Cape Colony, and there are consequently

three lines of fault-pits running in parallel courses, generally east and west, with a southerly turn on the eastern extremity.

The direction of the linear series is east and west, a course determined by the grain of the country—that is to say, by the general direction of the folds of the older rocks. That there should be a tendency to crack along these lines, and that the cracks should be in pairs, so that they throw down slips of ground between parallel faults, is a consequence depending on the general fracturing of the Indo-African Continent. This is too large a subject to be treated casually here, but we can say without fear of contradiction that these fault-troughs have a family resemblance to the great rift-valleys of Central Africa, and hence we can assume, without launching too far into the earth-movements that produced the rift valleys. I have stated realm of speculation, that they were caused by the same set of above that there was a tendency to crack in this manner and in this direction, but the tendency was only translated into actuality when the lines of potential faulting were crossed by another series of potential faults running in a north-easterly direction, or in a direction parallel to the straight coast-line on the eastern side of South Africa. These north-easterly faults, or rather potential faults, were also trough faults akin to the rift-valleys. We might put the case differently: each set of trough-faults was in itself not powerful enough to tear through the structure of the earth's crust, but where the two crossed each other, the strength of the earth's crust was so reduced by the double strain that it was unable to resist, and the fault-pit resulted.

The feebleness of the fault-lines in the south-west of Cape Colony indicates that they lie on the outer fringe of the great fractures. The existence of such potential or feebly developed fractures in the neighbourhood of the great fractures was beautifully shown in Daubrée's experiment in compressing a column of semi-plastic material. The column was made of a mixture of plaster of Paris, beeswax and resin, and was twice as long as in cross section; this was placed in a hydraulic press and compressed in the direction of its length. The column broke with diagonal fractures, the one large one starting from the top left-hand corner to the bottom right-hand corner, the other starting from the bottom left-hand corner and meeting the first about the centre of its course. Where the two fractures meet, there is shown this fringe of smaller cracks and lines of distortion without actual break, running in two series parallel to the main fractures, and dropping rectangular blocks between them.* The main fractures of the Indo-African fractures occurred just after the Eocene but before the Miocene Period, and these smaller fractures in the south-west of Cape Colony are of the same age. The two main troughs or lines of fault to which these latter are subsidiary, are represented

* A Daubrée, "Etudes de Géol. Expérimentale," Paris, (1879) [**2**]. Fig. 3.

by the great trough which is found in the sea-floor off our southern coast, beginning about south of Mossel Bay and running due east; the other is a similar trough beginning somewhere off Port Elizabeth and running north-east, parallel with the East Coast of South Africa. Had these troughs been on dry land they would have been called rift-valleys; as it is, they are obscured by the difficulty of reconstructing the exact topography of the sea-floor from a limited number of soundings, and are only shown with somewhat hazy margins in the most recent Admiralty charts. The fault-pits are always most extended in an east and west direction, but the east and west ends, though quite short, are invariably parallel to the north-east coast line and sea-trough.

The first line of the fault-pits begins with the two basins filled in with Uitenhage cretaceous deposits at Worcester and Robertson. The northern margins of these two are coincident with the previous fault-line which let down the Karroo beds against the Malmesbury beds. The next three belonging to this line also lie hard up against the foot of the Langeberg Mountains; they may be designated as the Swellendam, Riversdale, and Mossel Bay basins. The cretaceous conglomerates in the Riversdale area contain an extraordinary block of melilite basalt which is usually taken to be the top of a volcanic pipe, but the undisturbed nature of the loosely compacted conglomerates round it, and the inclination of faint lines of stratification in the lava, suggest that it may possibly be a giant meteorite. At Mossel Bay, at Cape St. Blaize, there is a small patch of cretaceous deposits to the seaward of the main basin, and separated from it by an area occupied by Table Mountain sandstone. This suggests that there may be a further line of fault-basins off our coast concealed under the water. The main line of the fault-pits belonging to what I have called the first series is continued by the basins at Knysna and Plettenberg's Bay, the latter being double, one on the coast running down the Pisang River, and the conglomerates in it jutting out to sea in the fine headland of Seal Point, and the other further inland, lying along the Bitou River.

The second or middle line of fault-pits begins with the great basin of Oudtshoorn, along which runs the Olifants River; it is constricted in the middle by a northerly spur of the Kammanassie Mountains. Here also the northern border of the fault-pit is coincident with the previous fault-line, which lets down the Bokkeveld beds against the Cango beds. The line is continued by five smaller basins along the Baviaans River, and ends in the basin at the mouth of the Gamtoos River.

The third or inmost line is represented by the wide area of Uitenhage beds around Uitenhage; it is made up of at least three smaller parallel troughs, which are concealed by the cretaceous beds which have covered the smaller details. This

line ends in a typical manner on the west at Glenconner, and on the east at the Alum Cave, on the Bushman's River, just east of where the main road from Port Elizabeth to Grahamstown crosses that river. At both ends the fault-pit dies out in a rounded curve, and the base of the cretaceous conglomerates is brought up to the general level of the surface of the country.

At one time we believed that the Uitenhage beds were contemporaneous in all three lines of fault-pits, but recently there has come to light certain evidence which suggests that there is a distinct time-interval between the deposits lying in the inmost or Uitenhage basin and the outer one. Most of the fossils described have come from the Uitenhage basin, but the following fossils have been found in the outer basins. In the Riversdale basin near Herbertsdale, a series of ferns, different in many respects to those of the Wood bed as developed at Dunbrodie, along the Sunday's River. At Knysna, in the estuary, a few marine fossils, such as *Perna* and *Trigonia*, also different from the fossils found in the marine beds along the Sunday's River. At Seal Point, *Trigonias* are found in the Enon conglomerate identical with those found in the Sunday's River beds in Uitenhage. Now, as the Sunday's River marine beds occur at the top of the Uitenhage series and the Enon conglomerate at the bottom, the presence of the same fossils in both at different places suggests that the Seal Point beds are of later date than those of the Uitenhage area. That is to say, supposing the order of the deposition of the beds was the same in all three lines of basins, as there is evidence to believe there was, in the Uitenhage the deposits, conglomerates, fresh-water beds and marine beds, had completed the cycle at a time when, in the area of the outer line of basin, the deposits were just beginning. In the Knysna estuary, the fossils, although there are so few, suggest that the beds are later than the typical marine beds of Uitenhage. The fossils from the fresh-water beds of Heidelberg are indefinite as regards whether they are earlier or later than the Uitenhage Wood Bed fossils; the chief fossil, a *Tæniopteris*, which does not occur in Uitenhage, is a long-lived form which we first meet with in the Jurassic rocks of the Stormberg.

Bound up with this question of want of contemporaneity in the deposits of the three lines of fault-pits is the question of the level of the floor on which the sediments were deposited.

The Oudtshoorn and Baviaans Kloof deposits were definitely laid down when the country was submerged 4,000 feet. Although there is no direct evidence in Uitenhage, there is nothing impossible in assuming that the conglomerates were once deposited on a floor which was level with the tops of the Zuurberg, 4,000 feet. But if we are to assume that the deposits in the first or outermost line are later in date than

those of the inner ones, then we must assume that the floor on which the former was deposited was higher than that on which the latter were. That is to say, when the deposits of the inner zone were being laid down, the outer margin from Worcester to Knysna was elevated, and not till the whole series of the Uitenhage beds had been laid down in the two inner lines of basins did deposition begin in the outer zone. The whole country sank as an iceberg would sink if weighted ; there is no evidence for any difference in the earth-movements of an elevatory or subsiding nature in the east and west, in all the movements we have yet been able to study in South Africa, in contrast to the more recent movements in South America. where the elevation on the side of the Andes has been greater than on the Atlantic side. There is nothing unnatural in assuming that there was a greater depression in and around the the great mountain ranges along the south coast than on the margin towards the sea. If we work out the problem in figures the elevations in feet are somewhat alarming, but when we come to consider the elevations and subsidences in the land in Miocene and Pliocene times, subsequent to these earlier movements, there is little to cavil at. With the base of the cretaceous deposits in the two inner lines of fault-pits at an original level of 4,000 feet above sea-level, in order to have the conglomerates of Seal Point contemporary with the Sunday's River marine beds at Addo, the base of these would be originally 6,500 feet, assuming that the thicknesses of the Uitenhage beds are 3,000 feet. Thus:—

Uitenhage Basin.		Seal Point.
Sunday's River marine beds, 500 feet.	=	Enon conglomerate.
with *Trigonia conocardiiformis.*		with *Trigonia conocardiiformis.*
Wood bed, 500 feet .. .. .. Enon conglomerate, 2,000 feet Original base above present sea-level, 4,000 feet	=	original base 6,500 feet above present sea-level.

To the total of the 7,000 feet submergence there must be added a further 2,000 feet to account for the covering of middle and upper cretaceous and Eocene beds which there is reason to believe at one time lay on top of the lower cretaceous deposits of Uitenhage; all signs of these later deposits have been denuded away in Cape Colony, but remnants of them are still preserved in Zululand and Madagascar.

I have not wished to touch on the matter of the faults in the East, in Pondoland and Zululand, because there are some disquieting features which would take us too far out of the

scope of this paper to discuss. Dr. du Toit has recently published his description of the Pondoland cretaceous deposits, and from their distribution he argues that they were laid down on a fault or steep monocline already formed; in other words, that the fault that bounds the eastern portion of South Africa was earlier than the upper cretaceous. The general participation of the Eocene in the fractures and folds of this system in India and Madagascar renders such a statement of extreme importance, and the evidence will have to be very carefully weighed before it can be finally accepted.

Dark Nebulæ.—Prof. E. E. Barnard, in a paper recently published in the *Astrophysical Journal,* reproduces some photographs of what are apparently dark celestial objects, and suggests that the visual perception of such dark bodies is due to a faint general luminescence of the background.

Deficiency Disease and Cottonseed Poisoning.—Rommel and Vedder have recently published an account of their experiments in connection with the so-called "cottonseed poisoning."* Cottonseed-meal is one of the most valuable feed-stuffs at the command of the American stockman, and after the animal has digested it, the value of the residue as a fertiliser is about three-fourths the original value of the meal. But cattle fed for three or four months on a heavy cottonseed-meal ration become lame, and often blind, sometimes leading up to a fatal result. In pigs sickness may appear after three weeks of feeding, and death often occurs with little warning. Experiments lead to the conclusion that this "cottonseed poisoning" is a deficiency disease, analogous to beriberi. Pigs are susceptible to beriberi when fed on vitamine-deficient rations. The disease manifests itself in pigs in two forms—acute and chronic. Acute cottonseed poisoning corresponds to wet beriberi and the chronic form to dry beriberi.

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THE EFFECTS OF DROUGHTS AND OF SOME OTHER CAUSES ON THE DISTRIBUTION OF PLANTS IN THE CAPE REGION.

By Prof. RUDOLF MARLOTH, M.A., Ph.D.

One of the special features of the flora of the south-western corner of South Africa, the Cape region, which extends from the Bokkeveldberg to the Van Staden Mountains near Algoa Bay, is the limited area occupied by many of its species. Quite a number of plants are known only from one particular locality, or a small district. Some of the best-known examples of this mode of occurrence are *Leucadendron argenteum*, the silver tree; *Antholyza Merianella*, called "flames"; *Disa purpurascens*, a near ally of *Disa graminifolia*, the well-known "blue disa"; *Cytinus capensis*, hitherto found only near Zeekoe Vlei*; *Serruria florida*, which is known only from a valley on the upper Berg River, etc.

Various causes have contributed to produce this state, the principal one being the great age of the Cape flora, which dates back into early tertiary times, or probably even further. But some of the peculiarities of distribution must be due to other causes, and some of these are operating even at the present day. The difficulty, however, is the shortness of the life of an observer in comparison to the fluctuations in the plant covering of a district, where no interference of man takes place, and the absence of records of sufficient accuracy in order to prove such changes.

Every instance in which such a change can be definitely established is consequently of unusual interest from a phytogeographical point of view, and the few observations which I am able to submit here are the first of their kind recorded in South Africa. These observations are of three kinds:

I. The spontaneous disappearance of a species from a locality without any apparent reason.

II. The disappearance of a species from a locality due to a natural change of the conditions of its existence.

III. The impoverishment of the flora of a locality, and perhaps of a district, through climatic conditions, *viz.*, an unusually severe drought.

I. THE DISAPPEARANCE OF A SPECIES FROM A LOCALITY WITHOUT THE INTERFERENCE OF MAN OR CLIMATE.

A striking illustration of the gradual spreading and sudden disappearing of a species without the interference of man by means of veld fires, draining, etc., was afforded recently on the southern slopes of Table Mountain at an altitude of about 2,700 feet. The locality is above the quarry at the Hely-Hutchinson

* The author has since received a specimen from Saldanha Bay also.

reservoir, and consists of a succession of rocky ledges with narrower or broader bands of level rocky ground between them. The whole of this slope, some 300 feet in height, was always covered with a luxuriant evergreen vegetation, consisting of various species of heath, *Psoralea pinnata, Euryops crithmifolius* and other composites, *Cliffortia ruscifolia* and numerous other shrubs and shrublets three to five feet high. In nooks and shelters formed by rocks, or descending gullies, abounded larger shrubs and small trees—*e.g., Podocarpus latifolius, Gymnosporia laurina, Olea laurifolia, Kiggelaria Africana, Protea cynaroides, Leucadendron decorum,* and, between specially damp cliffs, also dwarf trees of *Cunonia capensis.*

For many years I knew this part of the mountain as one of the few localities of *Erica gilva,* a shrubby heath generally three to four feet high, of the habit of the widely-spread *E. mammosa,* which is frequent in the Cape Flats and on the lower hills. Judging from memory, I should say that there were several hundred good-sized shrubs of this heath scattered about, conspicuous in midsummer on account of the large racemes of long, tubular, greenish-white flowers. Wishing to gather a few twigs of this heath last summer, I was surprised to find that it had practically disappeared from this slope, there being just one small bush left in the whole area. As I had photographed several groups of this heath there some years ago, I knew the locality in all its details, and was able to detect the remnants of some of the heath by the guidance of other shrubs there, *viz.,* some shrubs of *Psoralea pinnata* and *Protea cynaroides.* The dead sticks of some of the heath were still standing, showing that the shrubs had died in the natural course of events, *i.e.,* by old age, and not by any outside interference, such as a fire. Obviously all the shrubs must have started life nearly at the same period, perhaps after a bush fire, and no subsequent generations had developed there, probably owing to the incapability of the plants to compete against the more robust and closely-set undergrowth. When the age-limit of the shrubs was reached, which may have been in this case some 20 or 25 years, they simply gradually perished without leaving any progeny behind.

As the locality is partly fenced in—the ground belongs to the catchment area of the waterworks—and as I am quite certain that no bush-fire passed over it for many years, the gradual disappearance of the species from this spot, so to say, on its own account, could not be doubted, and this observation induced me to inspect several other places which I knew as habitats of this and another rather local, or rare, species. I then discovered that another very handsome species, *viz., E. vernix,* has also nearly disappeared from a part of the mountain where I knew it to have been plentiful in former years.

In both cases the disappearance cannot be due to the exceptionally dry summer of 1915, for it had taken place before

that period, hence the causes must have been others than merely climatic.

II. The Disappearance of a Species from a Locality owing to changed Environmental Conditions.

The well-known orchid, called the "Pride of Table Mountain," *viz.*, *Disa uniflora*, inhabits the banks of permanent streamlets and waterfalls of the south-western mountains, as well as ledges and crevices of rocks, which receive sufficient moisture, even in the dry season. Along one of the streams on Table Mountain, *viz.*, in the Arch Valley, I knew this disa to grow in profusion, having counted, on one occasion, about 26 years ago, over 200 blooms within a distance of less than half a mile. When visiting this locality last February I found, to my surprise, that most patches of plants along the stream had disappeared, and that this season had produced just fourteen flowers. One might feel inclined to ascribe the paucity of flowers to the extremely dry summer of 1915, and there is no doubt that in many places, especially on cliffs, the plants did not flower as freely as in normal years, owing to the absence of sufficient moisture. This stream, however, carried water, although less than in former years, and the disappearance of the plants themselves from the greater part of the banks of the stream cannot be ascribed to the paucity of water in the stream, which began to assert itself only in the beginning of the year. The cause is a different one. In the course of years the stream had gradually eaten its bed deeper into the soil, and while (at the time when I first visited it (about the year 1888), the banks were mostly less than a foot high, I found the channel now in many places 2½ or 3 feet deep, and the rushes (*Restiaceæ*) from both sides entangled to such an extent that one had to move them aside in order to find the bed of the stream. It is obvious that—(1) the upper part of the bank would be too dry for supporting the life of a *Disa uniflora*, which requires permanently moist soil all the year through; and (2) that many plants which might have survived in spite of the reduced supply of moisture were choked out by being deprived of light.

Whether, on an average, the stream did actually carry less water in recent years than 25 years ago, cannot be definitely stated, although I feel inclined to think that this is so, but the main cause of the dying out of the plants, or, rather, the great reduction in its numbers along this stream, is the deepening of the channel.

How far this deepening may have affected the composition of the other vegetation of the valley is not possible to say, but that it had destroyed at least nine-tenths of the disa plants is obvious from my observations.

III. The Impoverishment of the Flora of a Locality and of a Whole District through Climatic Conditions, *viz.*, a Severe Drought.

The indigenous vegetation of the Cape Peninsula as well as the introduced piants principally depend for the necessary water upon the winter rains, as the following table will show:—

Rainfall at the Royal Observatory, near Capetown.
The means (inches) calculated from a period of 22 years.

Jan.	Feb.	March.	April.	May.	June.	July.
0.82	0.59	1.10	2.16	4.17	4.05	4.12
Aug.	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Year.**	**Min.**
3.54	2.48	1.85	1.06	0.86	26.80	20.0

Rainfall for the Summer Months (mean).

Three months (Dec., Jan., Feb.)	Four months (Dec.-March)	Four months' Minimum for period of 60 years.
2.27	3.37	0.79 (1850/51)

It will be seen that while the four winter months (May-August) bring 15.88 inches of rain, the four summer months (December-March) show only 3.37. The real significance of this figure is, however, not apparent unless one examines the individual years from which the mean has been deduced, for while the minimum for the whole year is 20 inches—*i.e.*, 74.6 per cent. of the mean—the minimum for the four summer months during the last 25 years is 1.27—*i.e.*, 37.7 per cent. only, and in some neighbouring districts, *viz.*, Wellington and Piquetberg, it sometimes happens that no rain whatever falls during this period.

These are the years which decide the fate of many a plant which may have spread beyond the former boundary of the species, the fate of many a foreign tree, which may have grown to a considerable size during the years with an average or specially-favoured summer.

The summer of 1914/15 was such an extreme season, for not only the meteorological records, but also the effects produced, show it to have been so.

In the neighbourhood of Capetown one may see a good many full-grown trees of various kinds which died during this season, *viz.*, *Auracaria* (Norfolk pine), *Cupressus macrocarpa* (cypress), *Schinus molle* (the pepper tree), *Eucalyptus ficifolia* (the red flowering gum), and various other eucalypts, among them also the usually drought-resisting *Eucalyptus globulus* (blue gum). Of the latter species some fairly large trees, probably 50 years

old, succumbed, there being a whole row of such trees on the lower slopes of the Devil's Peak above Upper Mill Street.

Of the indigenous trees only the silver tree (*Leucadendron argenteum*) became conspicuous in this way, quite a number having died on the slopes of the Lion's Head and the Devil's Peak.

The summer was an exceptionally dry one, and the inhabitants of the Cape Peninsula will remember it for a good many years, for hardly within the memory of man had there been such a long spell of rainless weather.

Royal Observatory, Summer, 1914/15.*

Dec.	Jan.	Feb.	March.	Total 4 months.
0.51	—	—	1.82	2.33

Dec. 12-24	Dec. 24-31	March. 1-15	Three months, 12 Dec.-15 March.
0.13	—	—	0.13

From this table it will be seen that December, 1914, brought only 0.51 inches, and that during the period 25th December to 15th March, 1915—that means for nearly three months—there was no rain at all. The total for 3½ months (December, January, February, half March) was consequently only 0.51, while the average for the three months December-February is 2.27 inches, hence the season just passed brought only 22.5 per cent. of the mean.

As the summer advanced, the effects of the drought on the vegetation of the hills and slopes became more and more apparent, and at the beginning of March most of the purely herbaceous vegetation had disappeared. It will be convenient to group the observations under two headings according to altitude.

A. Western Slopes of Table Mountain (Camps Bay side) between the Pipe Track and the base of the cliffs. Altitude about 800 to 1,500 feet.

These slopes were formerly entirely occupied by a typical Cape Macchia, but, owing to the many veld fires which have swept over this area from time to time during the last century and even more recently, few arborescent elements of the original macchia have survived outside of the valleys cut by the streamlets which descend from the ravines of the mountain. All of these belong to Proteaceæ, *viz., Leucadendron argenteum,* the silver tree, and *Leucospermum conocarpum,* the kreupelhout, the former in a few specimens only, the latter scattered about or

* From data kindly supplied by Mr. S. S. Hough, H.M. Astronomer Royal at the Cape.

forming open groves. More socially were growing *Protea Lepidocarpodendron* and *Leucadendron plumosum*, of which one may meet some closely-set thickets not far from the Kloof Nek.

The principal shrubby constituents (4-6 feet high) of this impoverished macchia are *Cliffortia ruscifolia* and *C. polygonifolia*, *Passerina filliformis*, *Aspalathus chenopoda*, *Erica baccans*, and *Thesium strictum*, while among the still lower shrubs (2-4 feet high) none is more conspicuous than *Brunia nodiflora*.

Scattered among this world of pinoid, myrtilloid, and cupressoid foliage appear the large-leaved, but through bush fires much stunted and dwarfed, shrubs of *Protea grandiflora*, which in other more favoured and not fire-haunted localities grows to good-sized trees with trunks 12-18 inches in diameter.

It would take us too far to consider all the lower shrublets one or two feet high, for many species of heath, Thymelæaceæ, Penæaceæ, Leguminosæ, Rutaceæ, Composites, etc., abound here intermingled with several specially resistent species of Restiaceæ (*Elegia*, *Restio*) and Cyperaceæ (*Tetraria*).

It is among this vegetation that the effects of the severe drought of last summer have become specially conspicuous.

1. *Plants observed Dead.*

Leucadendron argenteum. Here and there.
Protea grandiflora and *Leucospermum conocarpum.*
Phylica buxifolia and *Coleonema album.* All those which had strayed too far from the borders of the (winter) streamlets.
Muraltia Heisteria. Frequently dead.
Anthospermum æthiopicum. Here and there.
Borbonia cordata.
Psoralea pinnata. Some large patches in the Platteklip Gorge quite dead.
Alciope tabularis, *Euryops crithmifolius*, *Osteospermum moniliferum*, and *Elytropappus rhinocerotis* here and there.
Erica baccans, *E. Plukeneti*, and *Lobostemon glaucum.* Occasionally.
Phylica capitata. This does not occur on the western slopes, but numbers of it were dead in Orange Kloof.

2. *Plants With Much Shrivelled Foliage, or, Although as a Rule Evergreen, now Without Leaves.*

The most conspicuous plant of this group was *Pelargonium cucullatum*, which in specially favoured localities had retained its foliage, but had dropped it in many other places. The bare stems, however, put forth fresh leaves soon after the first rains in March. Others are:

Cluytia pulchella, *Peucedanum Galbanum*, *Leonotis Leonurus*, *Salvia aurea*, *Polygala myrtifolia*, *Athanasia parviflora.*

3. By way of contrast, it is worth noting *that the following*

shrubs showed no effect of the drought, some of them looking as robust in their dark or dull green foliage as at ordinary times;

Brunia nodiflora, Asclepias arborescens, Gymnosporia laurina, and *G. buxifolia, Putterlickia pyracantha, Campylostachys cernua, Rhus mucronata* (with young foliage and fresh fruits), and *Philippia Chamissonis,* the largest representative of Ericaceæ in our flora.

4. *The following plants were found in flower* (March 7th): *Blaeria ericoides,* growing socially on some of the slopes; *Campylostachys cernua, Diosma vulgaris, Salvia Africana, Lobelia pinnatifida, Fagelia bituminosa.*

B. The Mountain Region.

On previous occasions* I have drawn attention to the great difference which exists between the mountains and their slopes with regard to the supply of moisture to their vegetation during the summer. While the records of rainfall for Cape Town or the Observatory actually indicate the amount of moisture deposited in their immediate neighbourhood, those of the mountain stations, say, above 2,500 feet, if we consider Table Mountain, give us only a portion of the total moisture deposited there, *viz.*, that fallen actually as rain.

Another considerable supply is, however, obtained by the plants from the south-east clouds, and this quantity has been shown to be very considerable. A dry and rainless summer like the last provided a remarkable demonstration of the efficiency of this last-mentioned source of supply. On the lower plateau of the mountain, altitude 2,450 feet, where the south-east clouds occur only occasionally, quite a number of dead shrubs and shrublets or other perennials were met with. I saw some dead shrubs of *Protea cynaroides* and *Leucadendron salignum,* some patches of *Berzelia lanuginosa,* isolated shrubs of *Stilbe vestita,* and considerable patches of *Centella eriantha,* wherever this plant had strayed too far from the banks of a streamlet. A conspicuous sight was also formed by the patches, or belts, of the dead plants of *Villarsia ovata,* which, during the period of an ampler summer rainfall, had been able to spread to many spots where it could not persist during this season.

Quite a different condition, however, existed on the summit of the mountain and the higher slopes. The only dead plants which I could detect there occurred on the outer edge of several swamps, which had become considerably smaller this year, as the second half of the summer brought comparatively little south-east wind. Here the dead leaves of *Villarsia ovata* and the dead culms of *Restio dichotomus* formed a brown belt around these spots, but in the remainder of this whole area I

* *Marloth, R.,* "Results of Experiments on Table Mountain for asecrtaining the Amount of Moisture deposited rom the South East Clouds." *Trans S.A. Phil. Soc.*, (1903) **14**; (1905) **16**.

could not find a single shrub, or shrublet, or other perennial which had died during the summer.

There is no doubt that the south-east clouds were the cause of this difference, and just as in the more outlying districts of the Cape region, *e.g.*, on the Bokkeveld, the Zwartebergen, the Wittebergen, etc., the lower limit of the Cape flora, as such, extends only as far down the mountain as the summer clouds reach, so we find on the Cape Peninsula the lower limit of the mountain flora at the lower level of the clouds, which, as far the northern and western sides of Table Mountain are concerned, would be about 2,000 feet above sea level.

In the absence of exact records it is impossible to say whether, through such an extreme summer, any species would become actually extinct within a certain area, but that many species are prevented from extending their domain, or rather, from retaining any new territory occupied in the years of good or average rainfall, must be obvious from the foregoing observations.

Potash in Alsace.—The scarcity of potash for manurial and other purposes, which is at present being felt all over the world, is drawing forth many suggestions for its extraction from sources either discarded or disregarded. Meanwhile M. Henri Blin, in the *Revue Générale des Sciences,* describes the potash deposits of Alsace. The beds are estimated to contain 3,000,000 tons of pure potash, almost enough for a five centuries' supply at the present rate of demand. Sylvinite—which mainly consists of potassium chloride—is the predominating mineral in the Alsacian deposits.

Astronomical Discoveries.—According to the report of the Council of the Royal Astronomical Society, submitted at the 96th Annual General Meeting, 56 minor planets were discovered and five comets observed during 1915. Of the comets, two, Winnecke's and Tempel's were returns of periodic comets of the Jupiter family previously observed, the former in 1819, and the latter in 1873. Two of the remaining three comets were discovered by J. E. Mellish, at Madison, Wisconsin, U.S.A., during February and September respectively. The fifth comet of the year was discovered by C. J. Taylor, at Claremont, Cape Province, on November 22: it was also a member of the Jupiter family.

AN ACTUARIAL ANALYSIS OF THE LOAN SCHEMES OF CERTAIN RAND BUILDING SOCIETIES.

By Prof. John Patrick Dalton, M.A., D.Sc.

§1. Rand Building Societies cater for three groups of clients:—

(*i*) *Savings Bank Depositors*, who are content with a comparatively low rate of interest (4 to $4\frac{1}{2}$ per cent.) in return for the greater security offered by first claim on the assets;

(*ii*) *Investors*, who take shares in the Society and run greater risks in the hope of realising larger profits (8 to 9 per cent.); and

(*iii*) *Borrowers*, to whom the Society lends the capital provided by depositors and investors, and who, having to provide the interest thereon as well as the expenses of management and ordinary profits (if any) of the Society, are called upon to pay interest at still higher rates (10 per cent.).

§2. Before entering upon detailed criticism, a little theory might well be reviewed. Whenever money is advanced on mortgage of depreciating securities, as is the case in Building Society operations, the loan is generally redeemed by a process of amortisation. The theory of the operation is simple. The loan repayments constitute a terminable annuity, of which the borrower is the vendor, and the Building Society the purchaser. The purchaser expects to obtain interest on his loan at a definite rate, and, furthermore, to have his capital still intact at the end of the term. Each payment, therefore, made by the borrower must be regarded as consisting of two parts: one, the interest element, providing interest on the loan at the rate agreed upon; and the other, the capital element, or sinking fund, constituting a repayment of capital. The sinking fund may be treated in either of two ways; it may be directly applied to the reduction of the capital debt, thereby reducing the interest element and increasing the capital element contained in the succeeding instalment; or, it may be carried to a separate capital redemption account, there to accumulate at the given rate until at the termination of the annuity, it amounts to the original value of the loan.

As long as a single rate of interest convertible with the same frequency is involved, there is no difference between these methods of treating the annuity payments; it is merely a matter of accounting. Thus, a loan of £1 is repaid by n equal periodical instalments, interest being at the rate of £i per £ per period. The instalment payable is $£\dfrac{i(1+i)^n}{(1+i)^n - 1}$. Of the first such payment interest absorbs £i, and the rest, say £f, goes to the reduction of capital. If the debt is diminished at once by this amount, the capital element contained in the next instalment is equal to f plus the interest saved by the reduction of the debt—that is to say, the capital element in the second payment is $f(1+i)$; this

is just the same as if the capital debt had remained unaltered and the sinking fund, f, had been invested at the rate i for the period. The capital element contained in the p-th instalment is $f(1+i)^{p-1}$; when that instalment has been paid the total reduction of capital (or the accumulated value of the sinking fund) is $\frac{(1+i)^p-1}{(1+i)^n-1}$, and consequently the redemption value, that is, the balance remaining unpaid at that stage is $\frac{(1+i)^n-(1+i)^p}{(1+i)^n-1}$. To a Building Society whose members have the right of redemption at any time, it is of importance that redemption schedules should be constructed for each of its loan tables, giving such an analysis of each repayment into its interest- and capital-elements; for the assets of such a Society, in so far as its loans on mortgage are concerned, consist of the unpaid balances thus determined; the profits during any period consist of the sum of the interest elements of all repayments made during that period, and, where such concerns are subject to income-tax, only the interest elements of the various repayments are taxable.

§3. All Building Societies operating on the Rand charge interest on their loans at a rate higher than any they could hope to obtain with safety from other investments. If, then, the sinking fund is not invested in the security of the debt itself, as is the case when each capital element is directly applied to the reduction of the loan, they are compelled to let it accumulate at a lower rate. In this case the annuity payments must be fixed so that the Society realises the higher (remunerative) rate on the loan during the whole term, while the sinking fund accumulates at the lower (reproductive, or accumulative) rate. This scheme is naturally less advantageous to the borrower than a single rate annuity at the same higher rate, for, not only has he to pay the higher rate on the unpaid balance, but he must also, during the whole currency of the loan, bring up to the higher rate the interest being earned by the sinking fund accumulating in the hands of the lender. When, however, the remunerative rate in a double rate annuity is less than that charged under a single rate scheme, a special calculation is needed to ascertain with which the advantage to the borrower lies.

§4. Rand Building Societies may be criticised from two points of view. In the first place an examination may be made of the soundness or otherwise of the attempts made at putting into practice recognised principles in the theory of finance—a startling commentary upon financial life in Johannesburg that such criticism is needed; and, secondly, an examination may be made of the terms offered to the borrower under the different schemes.

§5. *Bank Overdraft Scheme.*—Of seven of the chief societies operating on the Rand whose schemes here come under review, three (St. Andrews, Premier, and Goldfields) grant loans on the bank overdraft principle. In the first-named, a loan is granted at 8 per cent. The borrower guarantees a certain minimum repayment, but beyond that there is no fixity; the borrower may repay as much of his loan as he likes at any time, and future interest is chargeable only on the unpaid balance. This Society makes a feature of the fact that "there are no more complicated tables to consult"; but one one would think that dispensing with tables is practicable only in a small Society. The other two have regularised the scheme more. A loan is granted and is to be repaid in, say, n instalments; each instalment consists of $\frac{1}{n}$th of the loan together with interest on the unpaid balance, so that the actual sum payable diminishes each month. It is easily shown that for each unit of the loan under this scheme the capital element of the p-th payment made is $\frac{1}{n}$, the interest element is $i\left(1 - \frac{p-1}{n}\right)$, and the total sum actually paid for the accommodation is $\left(1 + i\frac{n+1}{2}\right)$. As far as total cost is concerned, this method is theoretically less onerous to the borrower than an ordinary annuity at the same rate of interest. The total cost of the latter is $\frac{ni(1+i)^n}{(1+i)^n - 1}$. This is always the greater, for the difference between them is

$$\frac{ni(1+i)^n}{(1+i)^n - 1} - \left(1 + \frac{n+1}{2}i\right)$$

Which may be written

$$\frac{(n-1)n(n+1)i^2}{2\{(1+i)^n - 1\}}\left[\frac{1}{3!} + \frac{2}{4!}(n-2)i + \frac{3}{5!}(n-2)(n-3)i^2 + \ldots\right]$$

a quantity which is essentially positive.

But the practical drawback to the scheme is the comparative largeness of the payments which must be made during the early years of the loan. To take an illustrative example, suppose a loan of £100 is to be repaid by 80 monthly instalments, interest being charged at the rate of 10 per cent. per annum. Repaying by single-rate annuity each instalment would be £1 14s. 4¼d., and the total cost £137 8s. 4d., whereas, on the

fixed capital-reduction scheme the first instalment should be £2 1s. 8d., the last £1 5s. 3d., and the total cost only £133 15s. But the early years of the loan have to bear the greater share of the burden, and as they are usually the lean years, the scheme might be open to objection on that account. Objection must be taken, also, from another point of view, to some of the methods adopted to put the scheme into operation. Here, for instance, is one of the tables:—

LOAN TABLE B

Class II.—£100 repayable in 80 Monthly Diminishing Payments at 6 per cent.(!) Interest as follows:—

	Subscriptions.			Interest.		Total.		
	£	s.	d.	s.	d.	£	s.	d.
During 1st year	1	5	0	17	6	2	2	6
,, 2nd ,, ...	1	5	0	14	11	1	19	11
,, 3rd ,, ...	1	5	0	12	3	1	17	3
,, 4th ,, ...	1	5	0	9	7	1	14	7
,, 5th ,, ...	1	5	0	7	0	1	12	0
,, 6th ,, ...	1	5	0	4	5	1	9	5
,, remaining 8 months	1	5	0	1	6	1	6	6

Although the capital is being reduced monthly, the interest payable is constant during each year; the borrower is therefore deprived of the interest on his sinking fund during each year, and gains no financial credit whatever for the monthly reductions of his loan. Moreover, the interest is stated to be 6 per cent. On the contrary, the rate is 10½ per cent at the beginning of each year, and, owing to the non-crediting of interest to the sinking fund, the rate rises to 12½ per cent. at the end of each year.

§6. *Single-rate Amortisation.*—The single-rate annuity scheme is favoured by three Societies—the Rand Provident, the Alliance (which has also a double-rate scheme), and the United. The interest charged is nominally 10 per cent. per annum. Of these Societies, the repayment schedules of the first-named are nearly, but not quite, accurate, those of the second are not disclosed in its prospectus, while those of the third are constructed on a peculiar and unsound basis which may repay more detailed consideration.

In §2 it was shown that the capital element contained in the p-th payment of such an annuity is $£\frac{i(1+i)^{p-1}}{(1+i)^n - 1}$ per unit of the loan; hence the capital elements contained in successive repayments form a geometrical series. In the repayment schedules published by the United Building Society, on the other hand, these elements form as nearly as possible an arithmetical series. This, as a matter of fact, does give an approximation to the correct value for the shorter period schemes; for, calling the

capital element of the first instalment, C_1, that of the p-*th* is $C_1\ (1+i)^{p-1}$, which may be written

$$C_1\ (1+\overline{p-1}\ .\ i+\frac{p-1\ .\ \overline{p-2}}{2!}\ .\ i^2+\ .\ .\ .\ +i^{p-1})$$

Hence if we were to neglect second and higher powers of i, we should obtain capital elements increasing uniformly, $C_1\ (1+\overline{p-1}\ .\ i)$; but the neglect leads to serious error, especially in the longer period tables. The consequences of this unsound method of construction of the repayment schedules are far-reaching; the following extract shows that, according to the Society's own figures it expects to earn up to 170 per cent. on the loan outstanding towards the close of the transaction.

EIGHT YEARS' TABLE.

Months run.	Redemption Value during this month. £ s. d.	Interest Element in Instalment just paid. s. d.	Rate per cent. per annum.
72	32 13 10	5 9	10.6
84	17 10 11	3 11	13.4
96	1 6 5	3 9	170

Comparison of these with the correct values given below shows that the outstanding debts, and consequently the assets of the Society, are consistently undervalued:—

Months run.	Redemption Value during this month. £ s. d.	Interest Element in Instalment just paid. s. d.	Rate per cent. per annum.
72	34 2 4	5 8	10
84	18 12 5	3 1	10
96	1 10 1	0 3	10

And we see how the neglect of squares and higher powers leads to cumulative errors which make their presence felt towards the end of the term.

Perhaps the most interesting result to which this basis of calculation leads is the following gem extracted from this Society's five years table:—

MONTHLY INSTALMENT, £2 2s. 6d.

Months run.	Redemption Value. £ s. d.
*	* * *
*	* * *
*	* * *
59	2 3 1
60	0 0 0

With one month still to run the debt amounts to £2 3s. 1d., at the end of the month it is only £2 2s. 6d. It is surely a new theory in financial practice that a debt grows smaller as it grows older.

§7. *Double-rate Amortisation.*—Two Societies—the Alliance and the S.A. Permanent Mutual—offer a double rate annuity scheme. In its prospectus the former does not disclose the remunerative rate, while its reproductive rate varies with the profits earned. The latter's scheme is clear and well-defined. The remunerative rate is 8 per cent. per annum, payable in monthly instalments; a reproductive rate of 5 per cent. per annum is guaranteed for the sinking fund, and to this is added extra profit, which has hitherto averaged 2 per cent. This scheme is reasonable and straightforward in its operation, and, as we shall see just now, it is more advantageous to the borrower than the ordinary 10 per cent. amortisation, even if the extra profit is only 1 per cent.

§8. *Comparison of Benefits.*—Having once settled which Societies are able to operate their schemes correctly, the borrower next inquires which scheme will offer him the least onerous terms. A common monthly payment seems to be the most satisfactory basis of comparison; for this payment we shall take the instalment payable in the case of the ordinary single-rate annuity, which amounts to $£\dfrac{i\,(1+i)^n}{(1+i)^n - 1}$ per unit of the loan. Now if a payment a is made m times a year in amortisation of a loan on which interest is charged at the rate of $£j_1$ per £ per annum, likewise payable in m instalments, the sinking fund accumulating at $£j_2$ per £ per annum, the accumulated value of the sinking fund at the end of n years is

$$\frac{\overline{1+j_2}^{\,n} - 1}{j_2}\left(a - \frac{j_1}{m}\right)\left(m + \frac{j_2}{2}\,.\,\overline{m-1}\right)$$

This result is used in the calculation of the figures given below. The first column gives the number of years during which payments are to be made; the second, the monthly payment made; and the other columns contain the sums to which those payments would amount under the different schemes, at the termination of the annuity.

Years Payable.	Monthly Instalment.			10% Single Rate Annuity.	Remunerative Rate 8% Reproductive Rate 5% Profits *nil.*			Remunerative Rate 8% Reproductive Rate 5% Profits 1%			Remunerative Rate 8% Reproductive Rate 5% Profits 2%		
	£	s.	d.	£	£	s.	d.	£	s.	d.	£	s.	d.
2	4	12	4	100	99	6	10	100	5	6	101	4	2
4	2	10	9	100	98	18	4	100	16	11	102	16	2
6	1	17	1	100	99	0	4	101	19	11	105	1	4
8	1	10	4	100	99	13	11	103	16	6	108	2	2

The existence of Building Societies which charge 10 per cent. for their loans so as to be in a position to pay high dividends to their shareholders depends upon the failure of the class of borrowers for whom they cater to recognise that, considering an ordinary loan on first mortgage can be raised at 7 per cent., a 10 per cent. rate is excessive. The precariousness of the position created by charging more than their money is worth is shown by the case of a wise borrower who takes up an ordinary bond at 7 per cent., and usues the Building Society only for the purpose of forming a sinking fund either in the Savings Bank department at 4 per cent., or by taking investor's shares earning, say, 8 per cent.

Years Payable.	Monthly Instalment.	10% Single Rate Annuity.	Remunerative Rate 7% Reproductive Rate 4%	Remunerative Rate 7% Reproductive Rate 8%
	£ s. d.	£	£ s. d.	£ s. d.
2	4 12 4	100	100 15 1	104 16 10
4	2 10 9	100	101 17 10	110 12 9
6	1 17 1	100	103 14 8	117 14 4
8	1 10 5	100	106 7 3	126 6 8

Borrowers are, of course, the life of a Society of this nature, and if, as is seen to be the case with those which offer a 10 per cent. amortisation, it pays borrowers to make other arrangements, the position of such Societies becomes essentially unstable.

Eugene Woldemar Hilgard.—Prof. E. W. Hilgard, M.A., Ph.D., LL.D., formerly Director of the Agricultural Experiment Station of the University of California, died on January 8th, three days after attaining his eighty-third year. Born when Liebig was thirty years old, Hilgard was for forty years the contemporary of the father of modern agricultural chemistry. During those forty years he became so thoroughly imbued with the ideals which formed the motive power of Liebig's enthusiasm and fame that the editor of the United States *Experiment Station Record** could truly say that his death marks "the passing of the last of the earlier group of pioneers in agricultural education and research." To-day, wherever agricultural chemistry is studied, the name of Hilgard, like the names of Gilbert and Lawes, possesses a widespread recognition approximating to that of Liebig himself. In Germany, the land of his birth, and in the United States, the land of his adoption; in Scandinavia, Hungary, and France; in Britain and in her colonies, his name and work have been honoured and esteemed. Liebig was fifty years of age when Heidelberg bestowed on young Hilgard the degree of Ph.D., and during the Liebig centenary Heidelberg reissued this degree to Prof. Hilgard as a "golden degree," in recognition of a half-century's work for science, while the Academy of Sciences of Munich

* (1916) **34** [4] 301.

bestowed on him the Liebig gold medal "for distinguished achievement in agricultural science." The universities of Mississippi, Michigan, Columbia, and California conferred on him the degree of LL.D., and the expositions of Paris, Rio de Janeiro and St. Louis presented him with medals for collaboration in agricultural research.

Hilgard's father, Chief Justice of the Court of Appeals of Rhenish Bavaria, emigrated to the United States when the boy was three years old, and settled on a farm, where the lad acquired a practical knowledge of agriculture. Judge Hilgard personally prepared his son for a university career, and at the age of 16 Eugene returned to Europe, studying at Zurich, Freiberg, and Heidelberg; graduating at Heidelberg with honours, and obtaining a doctor's degree *summa cum laude*. His thesis was the structure of the candle flame, in which he was the first to define four parts and to describe the chemical reactions proceeding in each part. Two years later Dr. Hilgard became assistant state geologist at Mississippi, and in 1858 state geologist, continuing meanwhile detailed investigations of the botany and agriculture of the State. It was then that he noted the sharp demarcations in the indigenous tree and plant growth on the different types of soil, and there the foundations were laid of the views which he afterwards developed in connection with agricultural investigation and soil surveys—views which have been worked out in detail in his many publications, and especially in his classic treatise on "Soils," published in 1906. Prof. R. H. Loughridge, once Hilgard's pupil and afterwards his colleague—who retired from the professorial staff of California University simultaneously with his veteran friend and quondam teacher—says, in this connection:—*

> While Hilgard was not the first to make a soil survey and chemical analyses of soils, he was the first to interpret the results in their relation to soil durability, fertility, and crop production. He was the first to maintain that the physical qualities and chemical characters of a soil go hand in hand in determining its cultural value, and he maintained that the complex character of a soil demanded an investigation into its chemical, physical, mineral, and biological characters if we would understand it fully.

The present writer had the privilege of receiving at different times from Prof. Hilgard many of his publications and the advantage of his criticism and counsel. He expressed himself on one of those occasions—in 1908—as greatly interested in the chemical soil work that had been undertaken in South Africa, and —two years later—as greatly pleased that in the initiation of that work regard had been given to the views from which Dr. Loughridge now quotes.

At the close of the civil war in America, Hilgard became Professor of chemistry in the University of Mississippi, and in 1871 his title was changed into Professor of experimental and agricultural chemistry. In the following year he transferred to

* *Science* (1916) **43**, 452.

the University of Michigan, and in 1874 to the University of California, where he remained until his retirement at an advanced age a few years ago.

During his whole career Hilgard was an active author: the writing of official reports and memoirs, of papers in scientific and agricultural periodicals, and of books—amongst the latter the treatise already mentioned—kept him constantly busy when not occupied in lecturing or in scientific investigation. The world needs men who will persistently lay stress on vaguely-grasped or forgotten truths. Hilgard was such a man. In the special branch of science which gave him fame he repeatedly emphasised such points as the potential fertility of arid soils, indigenous vegetation as a means of recognising soil character; the nature and reclamation of alkali soils; the distinction between what he called the "permanent stock of fertility" in soils, and their immediate productiveness; the need of unifying methods of soil analysis; and, last, but not least, the importance of giving the judgment of the practical farmer a patient hearing, and of discovering the scientific basis for that judgment.

Hilgard retired from his position at Berkeley Agricultural Experiment Station, California University, in 1909, and in the following May he wrote somewhat sadly: "I have been unable to read or write for several months past, and the end is not yet." He was fortunate in having lived long enough to realise the esteem of his *confrères* the world over. It is not generally known that he was at one time offered the post of United States Commissioner of Agriculture; and, on a subsequent occasion, the portfolio of Secretary of Agriculture: he recognised that his province was scientific rather than administrative, and so he declined the offers, and completed 35 years in the service of California University.

TRANSACTIONS OF SOCIETIES.

South African Association of Analytical Chemists.—Thursday, February 17th: J. Moir, M.A., D.Sc., President, in the chair.—"*The Industrial Fixation of Nitrogen*": H. **Schwarz.** The various methods suggested and adopted for the fixation of nitrogen were discussed, special consideration being given to Serperk's plant for the manufacture of aluminium nitride. "*Routine testing in a Dynamite Works Laboratory*": J. A. **Campbell.** Details of the methods adopted for testing the various products produced in a Dynamite Factory were considered.

Thursday, March 16th.—J. Moir, M.A., D.Sc., President, in the chair. "*Notes on the Kuils River Tin Mines*": Prof. G. H. **Stanley.** A short account of the occurrence of cassiterite and the method of hydraulic extraction was given.—"*Application of synthetic dye-stuffs and substitutes to cotton*": H. R. **Adam.** The method of dyeing cotton was described, consideration being given to substitutes probably now in use owing to war conditions.—"*Diseases of the Respiratory Organs in Miners, as recorded by Agricola*": Dr. J. **de Fenton.** A short account was given of the life and career of Agricola (1494-1560) and instances were mentioned where the translation by Hoover appeared to give a false impression of Agricola's knowledge of miners' diseases.

Geological Society of South Africa.—Monday, March 13th: P. A. Wagner, Ing.D., B.Sc., President, in the chair.—"*Notes on the Karroo System in the Southern Kalahari*": Dr. A. L. **du Toit.** The solid geology of the Kalahari is scarcely known because of the great development of superficial deposits over the area. During the military operations of 1915, when a continuous series of boreholes was being sunk, the author was enabled to examine the sections of Karroo beds so exposed. The information gathered sheds light on the stratigraphy of the Karroo beds much further north-north-west, within the South-West African Protectorate. The author proceeded to set forth his views on the correlation of these beds with those already well established. Through lack of palæontological data, however, it is not yet possible to confirm those views in all respects.

South African Institute of Electrical Engineers.—Thursday, March 16th: Prof. W. Buchanan, M.I.E.E., President, in the chair.—"*Description of the Kleinfontein Power Association's Plant*": G. **Graham.** The author gave a brief account of the scope of the Association and of the site of its power station, and then went on to describe the system of supply, the plant and its operation, the boilers, feed pumps, turbines, and condensers, circulating water pumps, generators, exciters, switchgear, and auxiliary supply.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, March 18th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair.—"*Notes on rare minerals in Madagascar*": T. P. **Waites.** The central portion of Madagascar, about 100 miles south-west of Tananarive, is extraordinarily rich in uranium and niobium minerals, which occur in pegmatite. Analyses were given of four uraniferous minerals, Blomstrandite, Betafite, Samiresite, and Ampangabeite, containing from 19 to 26 per cent. of UO_3 and from 23 to 45 per cent. of Nb_2O_5. The author predicted that the district will become the premier producer of uranium, and will enable radium to be obtained at a cost which will render it much more freely available than hitherto. Near Antsirabe, in a deep river cutting, a deposit of uranium phosphate is exposed, and it is also found in the district of Analalava, in the north-west of the island.—"*Analysis of Niobium-titanium minerals, with some new tests for niobium, tantalum, and titanium*": Dr. J. **Moir.** The author described an improved process for separating the constituents of euxenite, æschynite, pyrochlore, and similar minerals. The method is not quantitative. Four new reactions of niobic acid and niobates were described. The author also stated that niobium and tantalum, separately boiled in concentrated sulphuric acid, gave different reactions if treated with phenolic bodies on cooling. This led to the possibility of confirming niobium in the presence of tantalum. It was further stated that the thymol test for titanium is much intensified by adding sulphocyanide after reducing with zinc and hydrochloric acid.—"*Some new methods of testing for molybdenum*": Dr. J. **Moir.** The blue colour produced in the reduction of molybdic acid by nascent hydrogen is obtained as a specially sensitive test if the molybdic acid solution is faintly acid with mineral acid, and a few drops only of highly dilute stannous chloride are added. Hydrazine forms the best reagent for developing the blue colour. Other modifications of and improvements upon well known tests for molybdenum were described.

NEW BOOKS.

Lewin, Evans.—"*The Germans and Africa.*" $9\frac{1}{2} \times 6\frac{1}{2}$ in. pp. xviii. 317. Map. F. A. Stokes Co.: New York. 1915. $3.60.

Werner, A.—"*The language families of Africa.*" $7\frac{1}{2} \times 5$ in. pp. viii. 150. Sketch map. London: Society for Promoting Christian Knowledge. 1915. 3s. 6d.

ON THE OCCURRENCE OF *BACTERIUM CAMPESTRE* (PAM.) SM., IN SOUTH AFRICA.

By Ethel M. Doidge, D.Sc., F.L.S.

(Plates 8-11 and three text figures.)

In volume 2 of his work on "Bacteria in Relation to Plant Diseases," Dr. Erwin F. Smith states that nothing is known of the occurrence of *Bacterium campestre* outside of Europe and America, except that Kirk has recently reported it from New Zealand. It has been known for some years that a disease similar to that caused by this organism has been found attacking cruciferous plants in this country, but only recently has a favourable opportunity occurred for studying it in detail and establishing the identity of the causal organism. Investigation has shown that the trouble is extremely common and very widespread, and I think largely responsible for the failure of cabbages grown during the summer months.

Geographical Distribution.

The first record which we have of the disease is of a number of cabbage-leaves sent for examination from Barberton in 1906, and a little later from Mooi River, in Natal. In both cases the specimens were characterised by the blackened vessels of the fibro-vascular bundles, and yellowing of the affected parts. Bacteria were present in large numbers in the bundles.

In 1912, a farmer at Piet Retief reported the disease in two fields of cabbages and cauliflowers 150 yards apart; he complained that the leaves withered and turned yellow, and that some of the heads were quite rotten inside. Some time before writing, in looking through his crop and selecting cabbages for the market, a large cabbage fell to pieces as he was examining it to see whether it was hard enough to cut; later this plant developed a number of small heads, one of which he sent for examination. This specimen also showed the characteristic blackening of the veins and yellowing of the leaf tissues. The same symptoms were observed in some cauliflower leaves sent from the same locality, and in both cases there were innumerable bacteria in the fibro-vascular bundles

It was an outbreak of the disease in the writer's private garden during the winter of 1914, which afforded a favourable opportunity for studying the disease in the laboratory. A number of cabbage plants were attacked which had been obtained as seedlings from a local seedsman—a fact which will be referred to later in discussing the origin of infection—and this led to the discovery that the disease is very widespread and extremely common, and that in the neighbourhood of Pretoria anyway it would be difficult to find a garden entirely free from

it. In discussing the subject with local gardeners, I have found it extremely difficult to convince these men that their losses were due to a specific disease which might be prevented, and not owing to an inherent tendency of cabbages to "go wrong on account of the climate."

Up to the end of 1914, the "black rot" had only been observed in cabbage and cauliflower plants, but at the beginning of this year some experimental plots of kohl-rabi at Groenkloof were found to be badly infected. This was not to be wondered at, as the plots were not far distant from some cabbage plants which had been severely attacked.

In March of this year a crop of swedes in the neighbourhood of Johannesburg was attacked; the tops were fairly healthy, but the roots failed to swell out, and began to rot. The source of infection in this case is not evident; the discolouration was only present in the lower part of the root, and no blackened veins were observed in the leaves; but Smith and other investigators state that infection through the root system is not known. Inoculation experiments, which will be described later, showed this trouble, and that in kohl-rabi were identical with the "black rot" of cabbage and cauliflower.

Signs of the Disease.

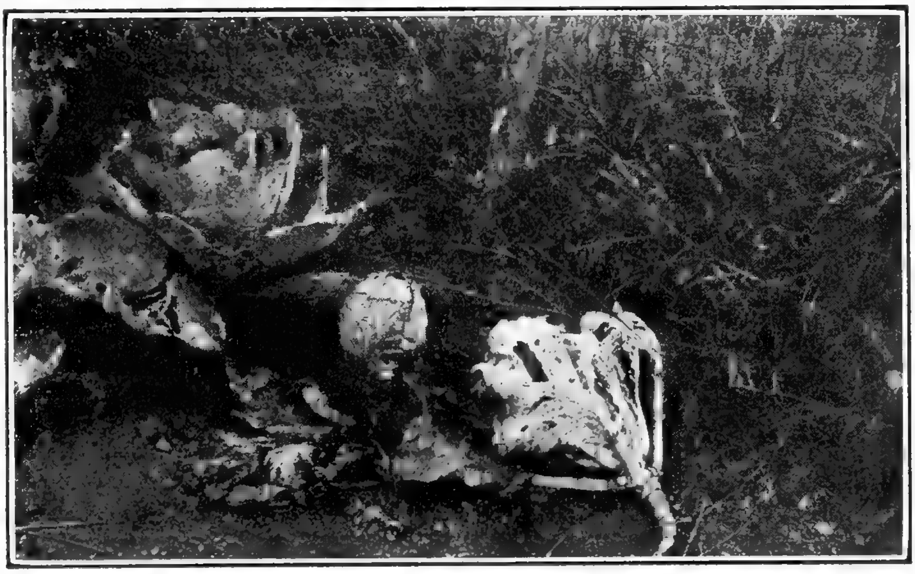
Some of the signs of the disease have been indicated in the previous paragraphs, and there is usually little difficulty in determining its presence; a more detailed description of the appearance of affected plants will, however, not be out of place here.

In cabbage and cauliflower the first sign of infection is the blackening of some of the smaller veins, usually in the neighbourhood of a water pore or of an insect injury. The tissues in the affected area become yellow, wilted, and rather leathery in texture (Plate 8). The dark brown or black stain spreads along the vascular system, and eventually invades the midrib of the leaf and the main stem of the plant. The stain in the thick petioles and main stem is frequently only visible on cutting them through (Plate 10, *a*).

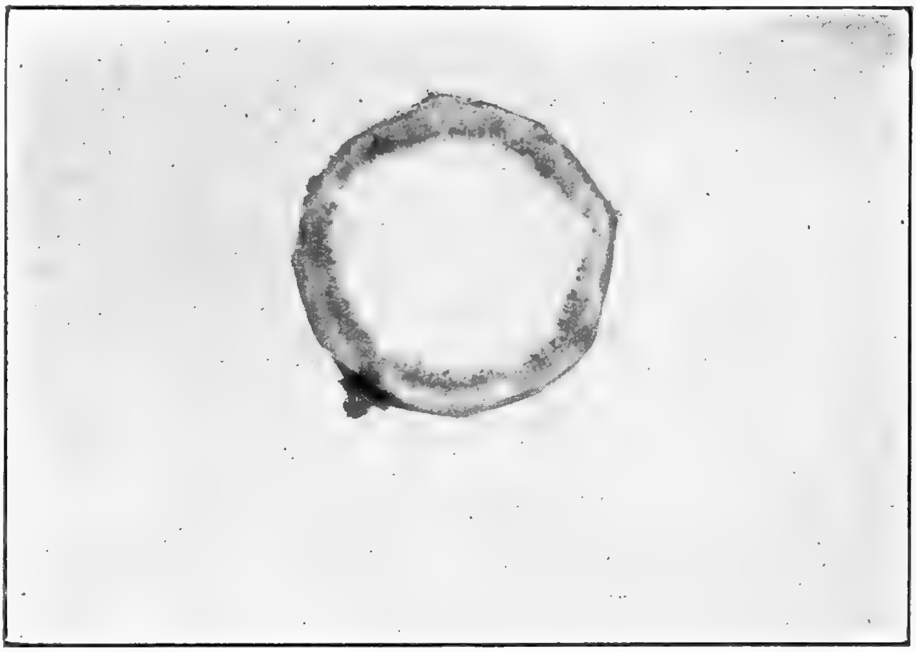
Severely affected leaves fall to the ground, leaving conspicuous leaf scars, and badly diseased plants present the appearance of a small terminal head separated from the roots by a long stem bearing the conspicuous scars of many cast-off leaves. Plants attacked early in the season or in the seedling stage are either killed outright or become so deformed and dwarfed that no head forms.

Cauliflower plants are affected in a similar way: the leaves show blackening of the veins and yellowing of the surrounding tissues; when badly diseased they fall, leaving conspicuous leaf scars, and frequently at the time when the head should be forming the plant consists of a scarred stem 2 to 3 feet long, surmounted by a loose terminal tuft of leaves. Cavities are formed in the stem, and the whole of the pith may be destroyed.

E. M. Doidge.—Bacterium Campestre.



a



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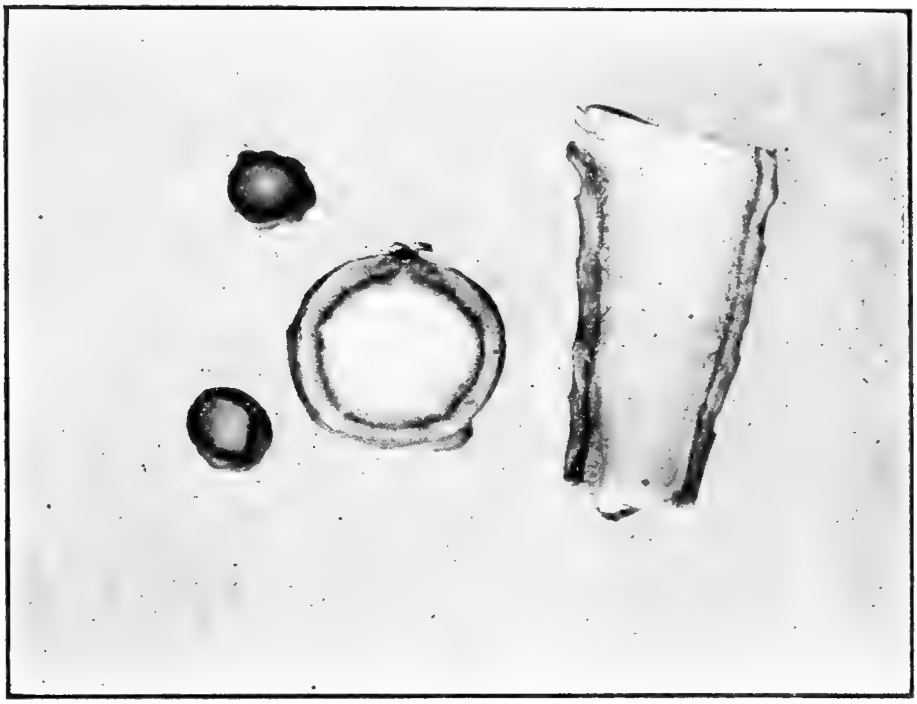
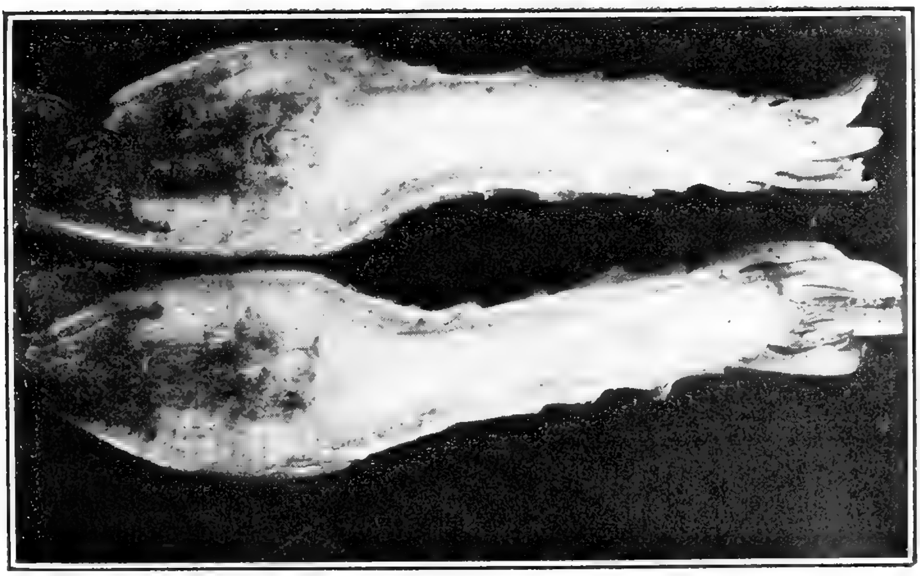
E. M. Doidge.—Bacterium Campestre.



a



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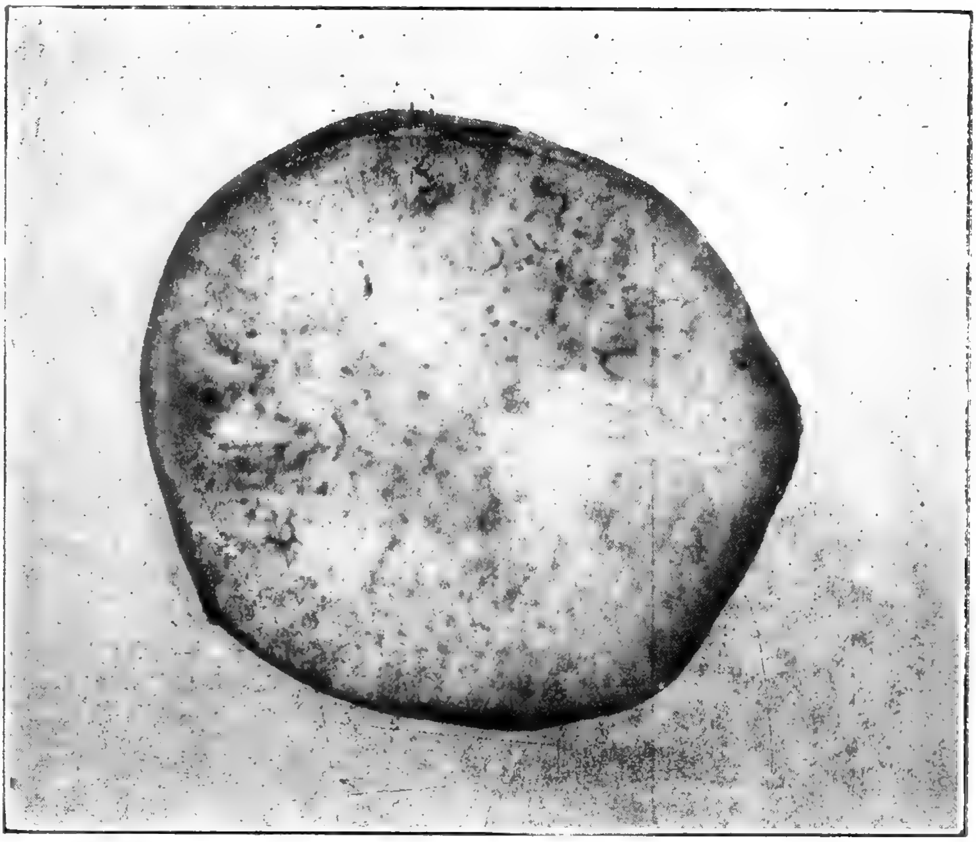
E. M. DOIDGE.—BACTERIUM CAMPESTRE.



a

b

E. M. Doidge Bacterium Campestre

The staining of the veins of the foliage leaves is also evident in diseased kohl-rabi, and the fibro-vascular bundles in the swollen stem are also conspicuously blackened (Plate 11, *a*). The stems fail to increase in size as they should do, and finally necrosis takes place and results in a large central cavity with a brown fibrous lining (Plate 11, *b*). Before they reach this stage, however, the plants are frequently invaded by soft rot bacteria, which rapidly complete the work of destruction.

In the specimens of swedes which have come under my notice, the leaves were comparatively healthy, but the roots failed to develope in the normal manner. When cut open the fibro-vascular bundles were found to be blackened, and in the majority of cases a central cavity was forming similar to that described as occurring in affected kohl-rabi plants (Plate 10, *b*).

The above-mentioned hosts are the only ones which have been found to be affected in this country up to the present, and the inoculation experiments conducted with pure cultures of the organism have been restricted to these plants, but in America Smith has also observed the disease in collards, kale, rape, rutabaga, charlock, and radish, and has successfully inoculated the majority of these plants. It is probable that, with continued observation, additions will be made to the list of hosts in which the organism occurs in South Africa.

Etiology.

A yellow, one-flagellate bacterium was isolated in September, 1914, from cabbages in the writer's garden, Pretoria, which showed typical signs of the disease. On September 25th, four young cabbage plants were inoculated by placing small quantities of an agar streak culture on the edge of the leaves; the plants were kept moist by covering them over with a bell-jar for 24 hours after inoculation. This precaution was also observed in all subsequent experiments. On the tenth day, small areas near the edge of the leaves were slightly wilted, and a closer examination showed a distinct discolouration of the veins; these symptoms were much more marked after another five days. Microscopic examination showed that the fibro-vascular bundles were covered with bacteria, and the organism was re-isolated without any difficulty. In another two weeks these seedlings were completely wilted off; the controls were perfectly healthy.

A second experiment was carried out under similar conditions, using young plants in pots. Six cabbages and three swedes were inoculated by needle pricks with a culture obtained from the same source as that used in the previous experiment. All the cabbages showed distinct signs of infection on the eleventh day; the swedes, unfortunately, were completely destroyed by insects. All the controls remained clean.

An experiment with swedes carried out on a larger scale was also unfortunate, the plants being destroyed by hail before any results could be obtained.

A small plot in the laboratory grounds was planted with about 36 cabbages in six rows. On November 24th these plants were all apparently quite healthy, and six cabbages in the row nearest to the fence were inoculated with a pure culture of the same origin as that used in the previous experiments, two by needle pricks in the midrib of a leaf, and four by placing traces of the culture on the leaf margins. The weather was warm and moist, the rains having set in during November, and signs of infection were quite evident on December 10th on the inoculated plants. All the plants on the remainder of the plot were perfectly clean, and remained so up to the middle of December, when the writer left Pretoria for a month. During that time the same weather conditions prevailed, over 20 inches of rain falling during December and January. On the 20th January the six cabbages inoculated were very badly diseased, consisting of a long stalk with conspicuous leaf scars surmounted by a loose head, and surrounded by fallen and decaying leaves. One of these was photographed, and is reproduced in Plate 9 *a*. The disease had spread right through the plot; those in the row most remote from the inoculated plants only showing a very few water-pore infections, but those in their immediate vicinity being badly affected.

On March 19th, a similar disease was noticed in some kohlrabi plants at Groenkloof Experiment Station; a yellow organism was plated out from these plants, and four young cabbage plants inoculated with the cultures. These readily contracted the disease, infection being very evident after about two weeks. The controls remained healthy.

A similar experiment was carried out using cultures obtained from diseased swedes; this inoculation was also successful.

It has been mentioned in an earlier part of this paper that the cabbages in the writer's garden which developed the disease had been obtained as seedlings from a local seedsman. On visiting the nursery where they had been grown late in November, I found that the disease was present right through the seed beds, and was thus being distributed right through the district, as people with small gardens usually buy seedlings rather than raise the plants from seed. An inspection of other nurseries would most likely lead to similar discoveries. In the case in question, the evidence pointed to the seed as the source of infection, and the nurseryman very kindly furnished me with a sample packet of each variety of seed which he had planted, and which had been imported from England. From these seeds a yellow organism was isolated; two cabbage plants were inoculated with the organism, and they readily contracted the disease. It is evident, therefore, that at least one source of infection is imported seed, it being impossible at this distance to ascertain whether the seed has been obtained from a healthy crop.

During the summer months, especially during the rainy weather, the disease spreads very rapidly, and develops rapidly in plants which are attacked. In winter, however, when the temperature is comparatively low, and there is no rain, the spread of the disease is reduced to a minimum, and in plants which become infected its progress is very slow. The central plant in Plate 9, *a*, was photographed two months after inoculation, the two months being December and January, when the weather was warm and moist. In winter it takes six to eight months for the disease to affect plants to the same extent.

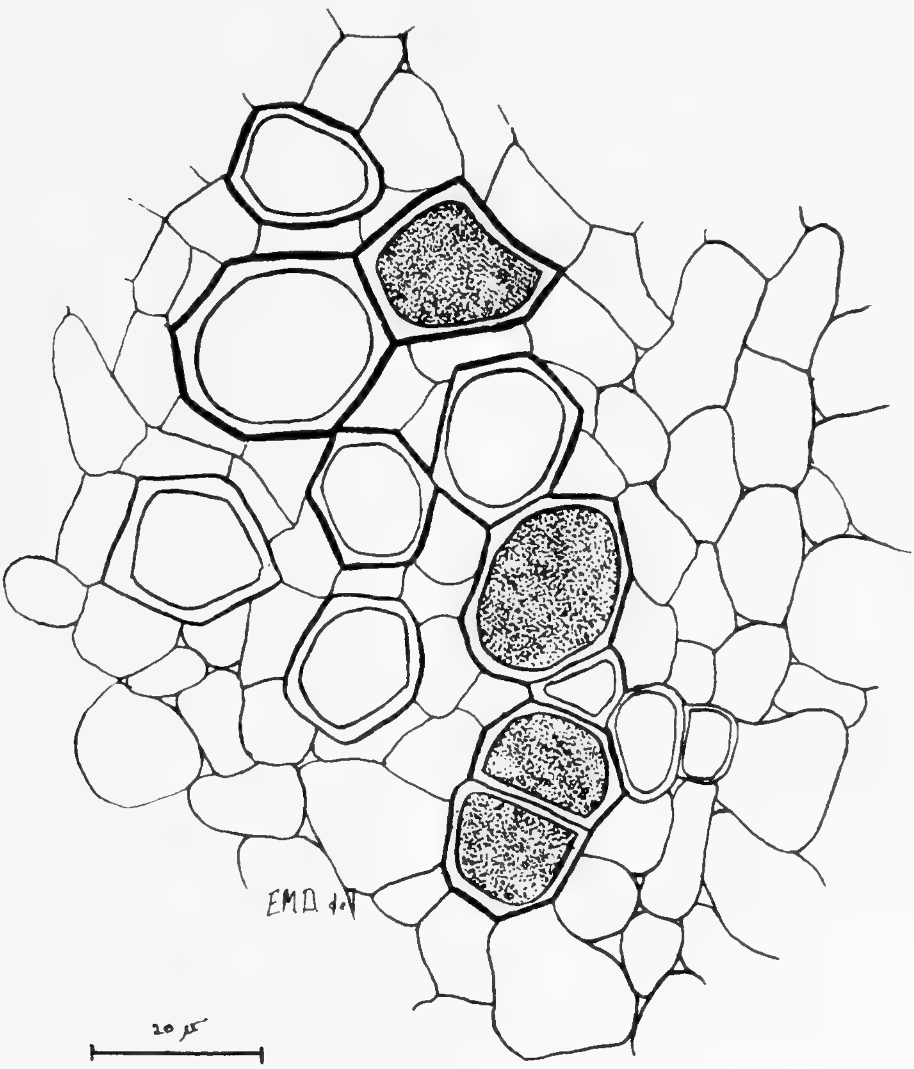


Fig. 1.

The question as to how far leaf-eating insects are responsible for communicating the disease in this country has not yet been fully dealt with. It is certain that a number of infections begin in close proximity to a hole made by such an insect, and a number of experiments have been started to discover how many of the common cabbage pests are responsible for the carrying of the disease, but no definite results have yet been obtained. These are being carried out with the co-operation

of Mr. D. Gunn, of the Entomological Division, and it is to him that I am indebted for information with regard to insect pests of cruciferous plants.

During the summer cabbages are infested with the larvæ of the cabbage moth (*Plutella cruciferarum*), and slugs are fairly numerous; both these pests disappear in the winter. The cabbage butterfly (*Plusia orichaleæ*) is known to occur, but is not plentiful. During the winter months the Bagrada bug (*Bagrada hilaris*) occurs very plentifully; it does not entirely disappear in summer, but becomes so reduced in numbers that it is a negligible quantity. The cabbage aphis (*Aphis brassicæ*) is also a great pest during the winter.

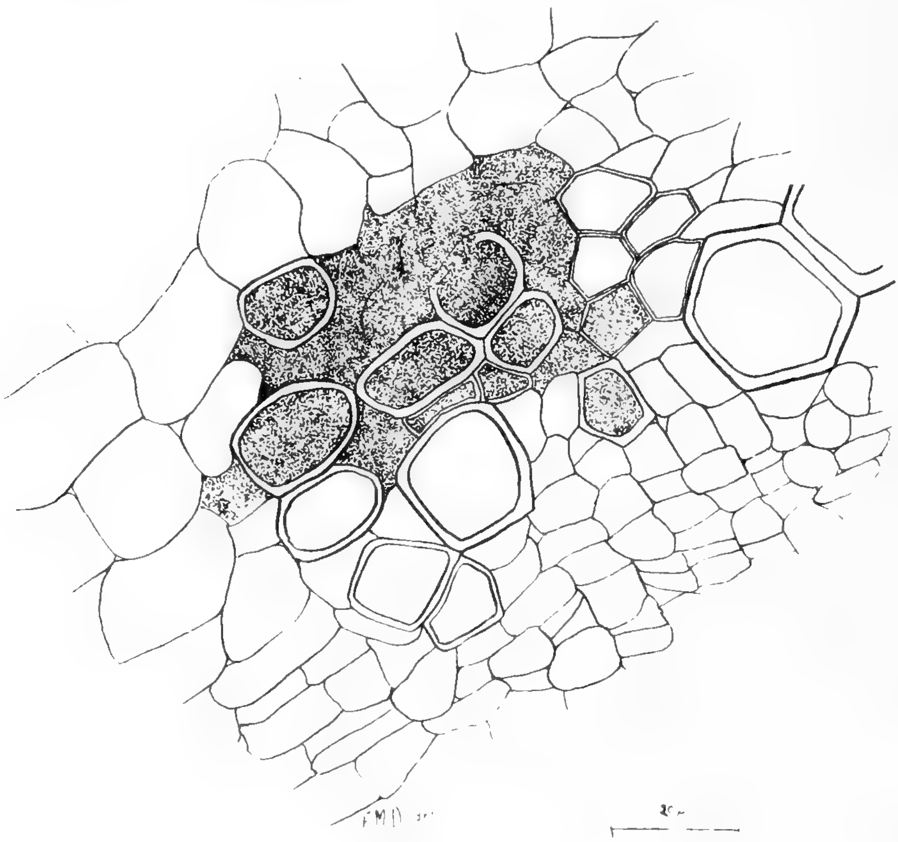


Fig. 2.

Smith has succeeded in transmitting the disease by means of the larva of the cabbage butterfly (*Plusia orichaleæ*), so there is every reason to suppose that the larva of the cabbage moth (*Plutella cruciferarum*) is also capable of carrying the infection.

He has also found that the disease may be carried by slugs, and Brenner reports successful transmission by aphides. It has yet to be determined whether the disease can be transmitted by the Bagrada bugs.

Water-pore infections, however, are by far the most common; during the summer weather a considerable number of these frequently occur on a single leaf.

Morbid Anatomy.

This is for the most part a disease of the vascular system, to which in early stages it is confined. The vessels of the fibro-vascular bundles, especially the spiral and reticulate vessels, are filled with innumerable bacteria (fig. 1). Bacterial occupation of the vessels is followed by the appearance of a brown stain in the walls. The vessels in the softer parts of the plant frequently become destroyed, and the bacteria invade the surrounding parenchyma (fig. 2). Cavities are formed, frequently involving the whole of the pith of the stem in cabbage, cauliflower, and kohl-rabi, and in turnips the entire root frequently becomes hollow.

The Parasite.

The organism causing the cabbage disease in South Africa is undoubtedly *Bacterium campestre* (Pam.) Sm. A short

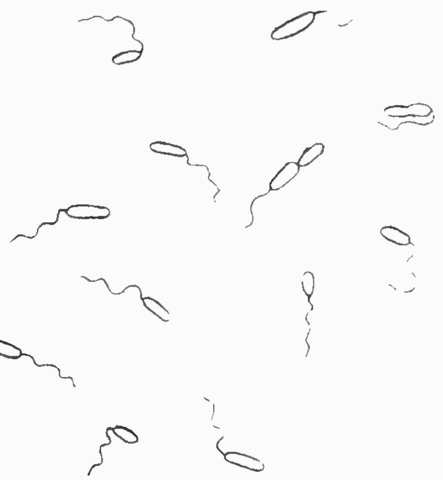


Fig. 3.

resumé of the characters of the bacterium isolated from diseased plants will be found to correspond in detail with the characters of *B. campestre* as worked out by Smith and other investigators.

The organism is a yellow schizomycete with a single polar flagellum (fig. 3); it is not, as a rule, motile when taken from the host plant, but is active in young cultures. It occurs singly or in short chains, but most frequently in pairs, and no capsules or spores have been observed. Its extreme measurements are $.7 - 3\ \mu \times .4 - .5\ \mu$, the length being much more variable than the breadth. It stains well with Ellis's modification of Loeffler's flagella stain, the single polar flagellum being two or three times the length of the bacterium.

The organism is yellow on all media; on a thinly-sown agar plate (+ 15 Fuller) kept at 30° C., in five days the organism developed thin, flat, circular yellow colonies up to 6 mm. diameter. In crowded plates the colonies are much smaller,

Submerged colonies were small, ellipsoid. Numerous feathery X-shaped crystals developed in old agar colonies.

On potato and cocoanut cylinders standing in water the organism formed a smooth, wet, shining yellow growth. A similar growth was produced on turnip cylinders, but was in this case accompanied by a brown discoloration of the medium.

Gelatine is slowly liquefied; in a stab culture the surface becomes liquefied, then the liquefaction extends downward, the solid surface of the gelatine being always more or less horizontal.

Litmus milk is blued and the casein slowly thrown down; it is not coagulated into a stiff mass, and the whey is extruded slowly.

The optimum temperature for growth is about 30° C., and the death point about 51° C.

The organism is aerobic, and there is no growth or gas formation in the closed end of fermentation tubes containing beef bouillon and 2 per cent. of the following carbon compounds—dextrose lævulose, saccharose, galactose, lactose, maltose, dextrin, mannite or glycerin.

Nitrates are not reduced; indol is slowly produced in peptonised beef broth and in Dunham's solution.

Treatment.

The fact that the organism has been found in a condition capable of producing infection on imported cabbage seed proves the necessity of disinfecting cruciferous seeds before planting as a precautionary measure. For this purpose Smith recommended soaking for 15 minutes in 1 : 240 formalin, or in 1 : 1,000 mercuric chloride. This treatment should kill all organisms present on the surface of the seed, and it does not affect the germinating power of the seed, as observed in a number of tests carried out in the laboratory.

Care should also be taken to destroy all diseased rubbish and to avoid land which has borne an infected crop. If insects are numerous, these should be reduced in numbers by the application of some suitable insecticide.

It has been suggested also that if the water-pore infections occur while the head is forming, the bacteria can be prevented from entering the head by removing leaves or portions of leaves. This treatment might be successful in the treatment of small plots, provided that too large a percentage of the leaves is not removed.

Summary.

A disease resembling the black rot of cruciferous plants, described in detail by Dr. Smith, of Washington, is very common in South Africa, but has not, up to the present, been identified as such.

It occurs in this country on cabbage, cauliflower, kohl-rabi and swede, possibly also on other cruciferous plants.

The disease is due to *Bacterium campestre* (Pam.) Sm., which has been isolated from diseased tissues, and a number of successful inoculations have been carried out.

The organism was found on imported seed offered for sale in Pretoria, and successful inoculations made with the culture so obtained.

A résumé of the characters of the South African organism is given, and these correspond with those of *B. campestre*.

It is suggested that as a precautionary measure all seed of cruciferous plants be disinfected before planting.

Explanation of Illustrations.

Plate 8. Leaves from a cabbage infected with "black rot"; the blackened veins are very evident. Natural infection. Groenkloof Experiment Station, near Pretoria.

Plate 9, *a*. Infected plants in Laboratory grounds. The cabbage in the centre was one of six which were inoculated with pure cultures of *B. campestre*. Photographed two months after inoculation, when infection had spread to neighbouring plants. For fuller explanation see text.

Plate 9, *b*. Section through stem of cabbage in centre of (*a*).

Plate 10, *a*. Transverse and longitudinal sections through stem of cabbage infected with *Bacterium campestre*.

Plate 10, *b*. Section through diseased swede.

Plate 11. Sections through kohl-rabi grown at Groenkloof Experiment Station.

a Shows characteristic blackening of fibro-vascular bundles. In *b* a cavity is forming in region of diseased bundles.

Fig. 1. *Bacterium campestre* from a 24-hour-old culture on nutrient agar; stained by Ellis's modification of Loeffler's stain. Drawn with *camera lucida*, Zeiss 1/12 oil imm. objective, and No. 12 compensating ocular.

Fig. 2. Section through fibro-vascular bundle of the stem of a cabbage seedling artificially infected through the water pores with a pure culture of *B. campestre*. Drawn with camera lucida, Zeiss 1/12 oil imm. objective, and No. 6 compensating ocular.

Fig. 3. Section through another part of the stem from which Fig. 2 was taken. Same magnification as Fig. 2.

In these two drawings the dots are not intended to represent the size of the bacteria, but only to indicate their distribution.

TRANSITION FROM ELEMENTARY ALGEBRA TO THE CALCULUS WITHOUT INFINITE SERIES.*

By Prof. W. N. Roseveare, M.A.

This paper divides itself into three parts:—

I. The details of the transition.
II. The introduction of the (natural) logarithm.
III. The method of approach to infinite series.

I frankly confess that I have no doubts left as to the wisdom of developing the idea of *limits* early. The student of mathematics has to face it in the geometry of a tangent and of the circle, in the definition of velocity (when not uniform), and, indeed, in the logic of everyday affairs. At tennis he uses his sense of sight and his conscious reasoning powers up to the last moment. The process by which he finally decides how and when to hit is almost exactly the mathematical "going to the limit." If we see two motor-cars approaching one another at 60 miles an hour, and within a yard of colliding, we need no further evidence of an actual collision.

This "limit" process may be simply described as following a train of reasoning applied to an increasing number of things as far as is necessary for conviction, and then giving full rein to the imagination as to the result to which this conviction will lead when the finite number of things becomes an indefinitely great number. We may add, as another apt illustration, the physical process of 'generalization'; for instance, Newton's Law of Gravitation.

Teaching experience leads me to the conclusion that the average student masters the idea readily enough; but the ordinary text-book does its best to nullify one's efforts. In the case of the tangent the books are quite sound—are with us. When we reach the regular polygon and the circle, the books refuse the word 'limit,' and thereby increase the teacher's difficulties. With some diffidence (because I think our Cape syllabuses in mathematics are generally very good), I venture to call "logically deplorable" the note in our Intermediate Syllabus: "It is to be assumed that it is impossible to distinguish between a circle and an inscribed regular polygon of a sufficiently large number of sides." The *imagination*, to which at this point we are specially appealing—the main difficulty is to make the student put down his pen, stop counting, and let his imagination work freely—has, of course, no difficulty whatever in making the distinction between a circle and a polygon, however large the number of sides. Why not "A circle may be regarded as the *limit* of an inscribed or circumscribed regular polygon when the number of sides is increased indefinitely"?

* In this paper no knowledge of Algebra is assumed beyond *indices*—no Progressions, no Binomial.

Again, when we come to velocity (rate of change of displacement), the opportunity of driving home the intrinsic limit idea in the word 'rate' is too often deliberately rejected by some such subterfuge as "the distance that would be traversed if the velocity remained constant" (the very thing it does not do). The geometrical progression to infinity is another excellent illustration ready to hand.

Having, I hope, made out a sufficiently strong case for seizing instead of burking every opportunity of getting the idea of limits established, I proceed to the details of the calculus.

I suggest using the words "rate of increase" of a function at first rather than "differential coefficient." The sense in which the rate of increase of x^2 is $2x$ is grasped easily enough; and I find it needs very little drilling in other easy cases to establish the fundamental proposition that "the rate of increase of $f(x)$ is the limit of $\dfrac{fx' - fx}{x' - x}$ when $x' = x$" as a natural consequence of simple ideas rather than the isolated but definite straw that some of us used to grasp in the dizzy whirlpool of "differential coefficients with regard to x."

The only continuous functions that at this stage have come within the student's experience are included in

$$x^n;\ \sin x,\ \sin^{-1}x;\ \tan x,\ \tan^{-1}x;\ a^x;$$
$$f(x)+\phi(x);\ fx.\phi x:\ \text{and } f(\phi x).$$

It seems strange that it has been so long the custom to import infinite series, with all their difficulties and pitfalls, into these fundamental differentiations.

It will probably be wise, in teaching, to consider first x^i: but we proceed to the general case. If $n = +\dfrac{i}{j}$ (integers),

writing X^j for x, we have

I. Rate of increase of $x^{i/j} = \underset{x'=x}{\text{Lt.}} \dfrac{x'^{i/j} - x^{i/j}}{x' - x} = \underset{x'=X}{\text{Lt.}} \dfrac{X'^i - X^i}{X'^j - X^j}$

=, dividing out $(X' - X)$,

$$\text{Lt.} \frac{X'^{i-1} + X'^{i-2}X + \ldots + X^{i-1}}{X'^{j-1} + X'^{j-2}X + \ldots + X^{j-1}} = \frac{iX^{i-1}}{jX^{j-1}} = nx^{n-1}.$$

If $n = -\dfrac{i}{j}$, we have

$$\text{Lt.} \frac{X'^{-i} - X^{-i}}{X'^j - X^j} = -\text{Lt.} \frac{X'^i - X^i}{X'^i X^i (X'^j - X^j)}$$

$$= -\text{Lt.} \frac{X'^{i-1} + X'^{i-2}X + \ldots + X^{i-1}}{X'^i X^i (X'^{j-1} + X'^{j-2}X + \ldots + X^{j-1})}.$$

$$= -\frac{i}{j}\frac{X^{i-1}}{X^{2i+j-1}} = -\frac{i}{j}X^{-i-j} = nx^{n-1}.$$

At this stage it will be well to prove the two very simple propositions on limits—that the limit of a sum or product is the sum or product of the limits.

Let A be a varying quantity which by any process tends to a limit a. Then at any stage $A = a + \alpha$, where α vanishes in the limit. So $B = b + \beta$.

Therefore $A + B = a + b + \alpha + \beta$; and $AB = ab + a\beta + b\alpha + \alpha\beta$.

Now in the limit $\alpha + \beta$, $a\beta$, $b\alpha$ and $\alpha\beta$ vanish (assuming a, b finite).

Therefore $\text{Lt.}(A+B) = a + b$ and $\text{Lt.}(AB) = ab$.

II. Rate of increase of $\sin x$

$$\text{is } \underset{x'=x}{\text{Lt.}} \frac{\sin x' - \sin x}{x' - x} = \text{Lt.} \frac{\sin (x'-x)/2}{(x'-x)/2} \cos \frac{x'+x}{2}$$

$$= \text{Lt.} \frac{\sin (x'-x)/2}{(x'-x)/2} \cdot \text{Lt.} \cos \frac{x'+x}{2}, \text{ which } = 1 \cdot \cos x \text{ (the angles}$$

being in circular measure).

So, the rate of increase of $\tan x$ is $\text{Lt.} \dfrac{\tan x' - \tan x}{x' - x} = \text{Lt.} \dfrac{\sin (x'-x)}{(x'-x) \cos x' \cos x}$

which $=$, as before, $\sec^2 x$.

III. For $\sin^{-1} x$, $\text{Lt.} \dfrac{\sin^{-1} x' - \sin^{-1} x}{x' - x}$, say, $\text{Lt.} \dfrac{\theta' - \theta}{\sin\theta' - \sin\theta} = \dfrac{1}{\cos\theta}$

$$= \frac{1}{\sqrt{1 - x^2}}.$$

Similarly $\tan^{-1} x$ gives $\dfrac{1}{1 + x^2}$.

IV. a^x needs special treatment.

$D(u+v) = Du + Dv$ without difficulty.

$D(uv) = u\,Dv + v\,Du$ as usual.

$$\text{and } D(fu) = \text{Lt.} \frac{fu' - fu}{x' - x} = \text{Lt.} \frac{fu' - fu}{u' - u} \cdot \frac{u' - u}{x' - x}$$

$$= \text{Lt.} \frac{fu' - fu}{u' - u} \cdot \text{Lt.} \frac{u' - u}{x' - x} = f'(u) \cdot Du.$$

$$D(a^x) = \underset{x'=x}{\text{Lt.}} \frac{a^{x'} - a^x}{x' - x} = a^x \,\text{Lt.} \frac{a^0 - 1}{0}$$

The question now arises whether $\dfrac{a^0 - 1}{0}$ has a 'limit.' Our previous work has given us no great acquaintance with such an expression. It might tend to become 0 or a; or $\dfrac{a^x - 1}{x}$ might tend to one limit as x approaches 0 by such steps as $\pm(1/2, 1/2^2, 1/2^3)$, and to a different limit when x approaches it by $\pm(\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \ldots)$. If we could ignore this latter difficulty, and

assume that it certainly tended to a limit uniformly, if at all, we could make x approach 0 by being continually halved; then, since $\dfrac{a^{2x}-1}{2x} \div \dfrac{a^x - 1}{x} = \frac{1}{2}(a^x + 1)$, which is greater (or less) than 1 when $a > 1$, according as x is $\pm$. $\therefore$ (for $a > 1$) $\dfrac{a^x - 1}{x}$, by this method of approach, continually diminishes when x is $+$, and continually increases when x is $-$. Now $\dfrac{a^x - 1}{x} \div \dfrac{a^{-x} - 1}{-x} = a^x$, which becomes 1 when $x = 0$, [and if $a < 1$, the function increases when x is $+$ and diminishes when x is $-$].

Thus $\dfrac{a^0 - 1}{0}$ is defined as the value to which $\dfrac{a^{\pm x} - 1}{\pm x}$ converge (for we have proved that they do converge) as x tends to 0.

As there is nothing to indicate any connection of this value with previously known functions, and as it presumably depends on a only, we give it a new name—the "(natural) logarithm" of a. [The old word 'logarithm,' to base 10, as used in previous arithmetic, is better not used—replaced by "ten index": it is ignored in this paper.] We proceed to prove from this definition the fundamental properties of this logarithmic function, and shall afterwards give a proof of its existence which does *not* assume uniform convergence.

$$\text{Since } \log a^{\alpha} = \underset{x \to 0}{\text{Lt.}} \frac{(a^{\alpha})^x - 1}{x} = \underset{\alpha x \to 0}{\text{Lt.}} \frac{a^{\alpha x} - 1}{\alpha x} \cdot \alpha$$

$$\therefore \log a^{\alpha} = \alpha \log a. \quad \ldots\ldots\ldots\ldots\ldots\text{(i)}.$$

And $\log(ab) =$ (assuming $b = a^t$), $\log a^{1+t} = (1+t). \log a$ $= \log a + \log a^t = \log a + \log b \ldots \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$(ii).

(i) includes $\log 1/a = -\log a$ and $\log 1 = 0$.

The result obtained in the course of the proof: $\log a$ lies between $N(a^{\frac{1}{N}} - 1)$ and $N(1 - a^{-\frac{1}{N}})$, is often preferable to expansion.

Excursus.—To remove the unsatisfactory assumption of uniformity of convergence we need to establish an inequality which is quite elementary, but is unfortunately deferred in our text-books while infinite series are (not very satisfactorily) discussed. *Viz.* $(1+x)^n$ lies between $(1+nx)$ and $[1+nx.(1+x)^{n-1}]$ for all values $+$ and $-$ of n and x, provided always that we remember that the theory of general indices assumes $+$ bases to the indices.

This proposition may be approached in two ways—(i) by establishing the (infinite) Binomial Series for negative integral indices, which is not difficult, and is perhaps desirable in an elementary text-book; or (ii) by proving that the geometric mean of a number of quantities is less than the arithmetic mean. Following this latter method,

(i) if $a' + b' = a + b$, $a'b' = a'(a + b - a') = ab + (a - a')(a' - b)$. Therefore, if a' lies between a and b (and therefore b' also), the product $a'b'$ is greater than the product ab.

I.e., a product is increased if the factors are replaced by two which leave the sum unchanged, but are more nearly equal.

Now consider $a\,b\,c \ldots z$, the product of n quantities.

Let μ be their arithmetic mean, so that $a+b+\ldots+z=n\mu$. Choose two of the quantities (a, z), so that a is greater than μ, and z less than μ (this is always possible, of course).

Then $az < \mu\,(a+z-\mu)$—call the latter factor z'.

Therefore $abc \ldots z < \mu .\ bc \ldots z'$, where $b+c+\ldots+z' = (n-1)\,\mu$., and $\therefore\ \mu$ is the arithmetic mean of $b, c, \ldots\ldots z'$. Make a similar change in the product $bc \ldots z'$; and, continuing the process, we get finally $abc \ldots z < \mu^n$.

$$\text{or } \underset{\text{in index}}{(abc \ldots z)^{1/n}} < \frac{1}{n}\,(a+b+\ldots+z).$$

(ii) Take for the quantities $abc \ldots z$, i quantities each 1, and the remaining j equal to $(1+x)$, where x has any $\pm$ value making $(1+x)+$.

$$\text{Then } (1+x)^{j/(i+j)} < \frac{i+j\,(1+x)}{i+j}$$

Therefore $(1+x)^n < 1+nx$ if n is a $+$ fraction.

Thence follows $(1+nx)^{1/n} > 1+nx/n$.

or, in other words, $(1+x)^n > 1+nx$, if $n > 1$.

$$\text{Now } 1+x = \frac{1}{1-X} \text{ say.}$$

$$\text{Therefore } (1-X)^{-n} > 1+nx = 1-n+n\,(1+x) = 1-n+\frac{n}{1-X}$$

$\therefore\ (1-X)^{1-n} > (1-n)\,(1-X)+n = 1-(1-n)\,X$.

But, n being > 1 here, $(1-n)$ = any negative quantity $\therefore$ generally $(1+x)^n > 1+nx$ when n is $-^{ve}$,
And, finally, $(1+x)^n \gtrless 1+nx$, according as x lies between 0 and 1 or does not.

Again, if $(1+x)^n \lesseqgtr 1+nx$, which $=(1+x)+(n-1)\,x$,
Dividing by $(1+x)^n$, $1 \lesseqgtr (1+x)^{1-n}+(n-1)\,x\,(1+x)^{-n}$,
therefore $(1+x)^{1-n} \lesseqgtr 1+(1-n)\,x\,(1+x)^{-n}$.
But $(1-n)$ lies or does not lie between 0 and 1 exactly as n does,
therefore $(1+x)^n$ lies between $\left|\begin{matrix} 1+nx \\ 1+nx\,(1+x)^{n-1} \end{matrix}\right|$ for all possible values of n and x, $(1+nx)$ being the upper limit if n lies between 0 and 1, but the lower limit if n lies outside 0, 1.

$$\text{We may write the result in the form } \frac{a^n-1)}{n(a-1} < \left|\begin{matrix} 1 \\ a^{n-1} \end{matrix}\right|$$

$$\text{whence, writing } a^x \text{ for } a \text{ and } \frac{x'}{x} \text{ for } n,\ \left(\frac{a^{x'}-1}{x'} \div \frac{a^x-1}{x}\right) < \left|\begin{matrix} 1 \\ a^{x'-x} \end{matrix}\right|$$

Whence follows the reasoning by which on a previous page we established the existence and properties of 'the logarithm,' and we have $D\,(a^x)=a^x \log a$.

Since a^x is a continuous function of a (so long as a is $+$), it follows from the above that log a $(a+^{ve})$ continually increases with a from $\log 0 = -\infty$ through $\log 1 = 0$ to $\log \infty = +\infty$. Hence there is some value of a (always called e) for which $\log e = 1$, and $D.e^x = e^x$

In my view of these functions e is always subordinate to log; in fact, e^x is merely a (more convenient) form of $\log^{-1}x$. In the same way $\cos x = \frac{1}{2}(\iota^x + \iota^{-x})$ is to me more satisfactory than $\frac{1}{2}(e^{\iota x} + e^{-\iota x})$.

V. *The Hyperbolic Functions.*—These do not force themselves on our notice until we come to integrate such things as $\sqrt{(1+x^2)}$. It is unsatisfactory to introduce them arbitrarily as mere names for $\frac{1}{2}(e^x + e^{-x})$.

They originate better thus :—

If we have to deal with pairs of quantities u, v the *sum* of whose squares is 1, Pythagoras' Theorem at once suggests the co-ordinates of a point on a unit circle: and the ordinary Trigonometry follows inevitably.

But if we wish to deal with pairs of quantities the *difference* of whose squares is 1, $u^2 - v^2 = 1$ leads to $\left.\begin{array}{l} u+v=a^x \\ u-v=a^{-x} \end{array}\right|$ where a, x are arbitrary.

Therefore $u = \frac{1}{2}(a^x + a^{-x})$ and $v = \frac{1}{2}(a^x - a^{-x})$.

And if now we differentiate these new functions (of x),

$Du = \frac{1}{2}(a^x - a^{-x}).\log a = v.\log a$; $Dv = u.\log a$.

If, therefore, a is taken to be e, $Du = v$ and $Dv = u$.

Thus the only reason for defining cosh x and sinh x as $\frac{1}{2}(e^x \pm e^{-x})$ is analogous to that for using circular measure of angles—that $D \sin x$ and $D \cos x$ may not involve an inconvenient constant factor.

The essential property of cosh x, sinh x is $\cosh^2 x - \sinh^2 x = 1$.

D (tanh x, etc., $\sinh^{-1}x$, etc.) follow easily.

VI. Having now obtained the rate of increase of all the known functions and Algebraic combinations of them (including the new functions—logarithmic, exponential, hyperbolic), with the one additional remark that the process called differentiation can be repeated and denoted by D, D^2, D^3, . . . or $f'(x)$, $f''(x)$, . . . we pass to Integration. To a great extent integration is the only logical sequel of Newton's and Leibnitz' idea of differentiation; so that it is natural and desirable to develop and teach integration as soon as differentiation is grasped.

The 'Summation Theorem' and the derivation from $D(uv) = uDv + vDu$ of the process known as 'Integration by Parts' are, as given in the text-books, sound and straightforward. I do not propose to comment on them here, but to use them to establish Maclaurin's (including Taylor's) Theorem with an exact remainder, and to suggest this as the fundamental basis of infinite series rather than the subtle (and in many ways hazy) special processes known as the Binomial, Exponential, logarithmic

Theorems which have to be buttressed by theorems on 'Convergence'—

[Of course, the one fundamental test of convergence, that $u_n/u_{n-1} = a + \frac{b}{n} + , \ldots$ where either $a < 1$, or $a = 1$ and $b > 1$, is necessary as a test of the intelligibility of any infinite series that may arise: but it is unnecessary and undesirable to nterpose somewhat amorphous Higher Algebra between simple Algebra and the Calculus. The trend of modern mathematics is to jett son this Higher Algebra; and the one object of this paper is to attempt to show how this can be done with not loss but gain of security and completeness in our foundations, and so to show how the Calculus can be made readily accessible to the average Cape Intermediate student].

$$\text{Since } f(x) - f(o) = \int_o^x f'(x)\,dx$$

(changing x to $x - z$).

$$= \int_o^x f'(x-z)dz.$$

$$\text{Integrating by parts, } = xf'o + \int_o^x z.\,f''(x-z)dz.$$

$$= xf'o + \int_o^x f''(x-z).d\frac{z^2}{2}$$

And repeating this process,

$$f(x) = fo + xf'o + \frac{x^2}{2!}f''(o) + \ldots + \frac{x^{N-1}}{\overline{N-1}!}f^{N-1}_{(o)}.$$

$$+ \text{ a remainder } \int_o^x f^N(x-z).d\frac{z^N}{N!}$$

with the conditions, involved in our proof of the Summation Theorem, that $f(x)$, $f'(x)$ and the higher derivatives are continuous from o to x of the variable.

Thus Maclaurin's Theorem holds as an infinite expansion if this remainder $\int_o^x f^N(x-z)\,d\frac{z^N}{N!}$ tends to o as $N \longrightarrow \infty$

Lagrange's remainder follows easily, and is not, it seems to me, worth proving in any other way.

But, as is well known, Lagrange's remainder fails to settle the convergence of the Binomial and logarithmic series.

These are settled by means of a simple change of variable in the above Integral. The processes are hardly worth our time in such a gathering as this—but were too much for Honours students last year. I will conclude my paper with two more abstruse remarks:—

(i) *Differential coefficients versus Differentials.* Differentials (*i.e.*, bare dx, dy) can be used in an expression whenever the omitted denominator can be regarded as implied—*e.g.*,

$x^2+y^2=a^2$ gives $xdx+ydy=o$, because "division by" dx gives the proper Leibnitz form; but $adx+bdy=c$ is meaningless.

(ii) One often wonders what 'expansion' in power series means psychologically—why should we be so anxious always to expand in powers of x? We can answer the question in the case of our ordinary decimal notation: the process is an extremely convenient way of counting with 10 (or rather 9) figures and recording each complete cycle.

But the more general process involved in Maclaurin's Theorem has a more elusive *raison d'être*. Is it really, as it seems to us, logically inevitable? Could mathematical reasoning have developed satisfactorily on other lines and missed 'expansion'? The only semi-answer that I can give myself to these questions is that expansion is a form of integration by parts, which is apparently an inevitable sequel of integration itself; and integration is a fundamental logical process, inevitable to the human mind.

South African Homoptera.—Of all the orders of insects in South Africa, the Hemiptera, and particularly the sub-order Homoptera, have been studied the least, and the list of described species would scarcely number more than one hundred. Mr. E. S. Cogan, M.A., has recently contributed to our knowledge of South African Homoptera the results of his study of a series of South African Cercopidæ and Jassoidea, hitherto scarcely known at all, which had been sent to Ohio State University by Mr. C. W. Mally, of the Department of Agriculture, Capetown. In all some 38 forms were studied, and the results have now been published.* In the course of his descriptions the author observes that the practice of burning the veld, though not very strongly recommended by botanists, nevertheless serves to keep down the grass-feeding species of Jassids. The protective resemblance to plants and flowers borne by many African Homoptera are specially mentioned.

* *Ohio Journal of Science* (1916) 16 [5] 161-200.

THE AGGLUTINATION TEST; WITH PARTICULAR REFERENCE TO ITS USE IN THE CONTROL OF CONTAGIOUS ABORTION IN CATTLE.

By Eric Maxwell Robinson, M.R.C.V.S.

To the student of general biology there are few subjects which are of more interest than the properties of the blood-serum of an animal, including the reactions to invasions of foreign elements, such as bacteria, protozoa and albuminous substances of various kinds. It is with one class of antibodies produced as a result of the invasion of the animal body by bacteria that I wish to deal in this paper, namely, the agglutinins or substances which cause clumping of the invading organisms. For the detection of the presence of agglutunins in the serum of an animal, a test has been devised which is called the agglutination test or Grunbaum-Widal reaction. The agglutinins and agglutination will first be described, after which the actual technique of the test will be given and its application discussed in connection with the control of such a disease as contagious abortion in a herd of cattle.

The presence in blood-serum of substance which could cause the agglutination or clumping together in masses of organisms was first noticed by Gruber and Durham in 1896, during some experiments with antiserum against the cholera organism. These workers found that the serum produced by immunising an animal against cholera had the power of agglutinating cholera organisms. In their experiments they added cholera antiserum to a broth culture of cholera organisms, with the result that the organisms formed small visible clumps in the fluid, which fell to the bottom of the test-tube, leaving the previously turbid broth perfectly clear. This agglutination was found to occur with other organisms and their antisera, and it was then recognised that agglutinins were produced by most kinds of bacteria.

The process of agglutination can be watched in a test-tube containing a faintly turbid emulsion of an organism and its antiserum. The process takes place most rapidly at the temperature of the animal body, i.e., 37° C. or thereabouts, so that the test-tube has to be incubated. If one closely observes the turbid fluid, one first notices that it is becoming finely granular, which is best seen by comparing with a control tube containing only bacteria without any antiserum. These fine granules will be seen to be moving, some rising, others falling, but eventually larger granules form, and then finally small masses of bacteria, which fall to the bottom of the test-tube, and the fluid is left quite transparent and clear as water. An ordinary suspension of organisms remains turbid for a long time, and never leaves a clear fluid over the deposit at the bottom of the test-tube. Complete agglutination usually takes about a day, but the length

of time required varies greatly with the particular organism and the strength of the antiserum. The deposit in complete agglutination is quite typical as compared with an ordinary deposit of organisms. In the latter case the deposit is round and well-defined, occupying the least possible space, and when examined under the microscope the organisms will be found to be packed neatly together. In the former case the deposit resembles either a thin veil with waving edges or an irregular star-shaped mass, and on microscopical examination the organisms appear to be lying in disordered masses as if they have suddenly been thrown together without any attempt at arrangement. In a hanging-drop preparation, which is made by placing a drop of the culture and its antiserum on a cover-slip and inverting it over a slide with a well in it, one can watch the whole process of agglutination under the microscope. In this case one notices first that the organisms, if motile, lose their motility, and then run slowly into masses, leaving the intervening fluid quite clear.

Other cells besides bacteria may be agglutinated, and it has been found that fresh cattle serum possesses the power of strongly agglutinating the red blood corpuscles of various other animals, though these agglutinated corpuscles usually afterwards undergo hæmolysis, that is to say, they are destroyed and their hæmoglobin liberated. Sheep's blood corpuscles are agglutinated but not hæmolysed by fresh cattle serum. It is not intended in this paper to describe any agglutinins except those which are produced by bacterial infection, as the agglutination of red corpuscles is a study in itself.

Speaking generally, the reaction of agglutination is specific, and the antiserum against the typhoid bacillus will not clump the cholera or Malta fever organisms, and the serum of a cow infected with contagious abortion will not clump the glanders bacillus, etc. Group reactions with closely allied species of bacteria do, however, occur, a case in point being the agglutination of typhoid and also paratyphoid bacilli by the same antiserum. The difficulty in such a case can be overcome by using very dilute antiserum, as it has been found that the anti-typhoid serum will agglutinate typhoid bacilli when diluted 80 or more times, whereas it will not agglutinate paratyphoid bacilli when diluted more than at most 50 times. These group reactions are very useful in the classification of bacterial species, and have added much further evidence to that previously obtained by comparison of size, special staining reactions, appearance of growth in particular media, etc.

Bacteria which have been acted on by an agglutinating serum are not in any way altered either in appearance or virulence. What the actual benefit the animal receives by agglutinating invading bacteria is not known, but it has been thought that by being rendered immobile they are made a more easy prey for leucocytes, though it has been noted that ingestion of bacteria or phagocytosis may be almost absent in a disease

where agglutinin production is very marked. The amount of agglutinin present in an animal's serum is no index of the degree of immunity possessed by the animal, and it may be immune to a disease after it has lost the power of agglutinating the organism which caused the disease—in fact, agglutinin production only continues as long as the organism is in the body.

Agglutinins are thermo-stable antibodies, which means that they will resist heating to 56° C. for half an hour without losing their properties. At a temperature of between 62° C. and 70° C. they become what is called agglutinoid, which means that they combine with the bacteria without causing them to clump at all. Curiously enough, it has been noticed by Dreyer that agglutinoid when boiled for an hour or longer will regain the power of causing agglutination of bacteria. The fact that agglutinoid combines with the bacteria is easily proved by adding a serum which has been heated to 70° C. for half an hour to an emulsion of bacteria. The mixture is centrifugalised, and the sedimented bacteria are taken away and added to a fresh serum which is known to agglutinate the species of bacterium which is being used in the experiment. No agglutination will now take place, proving that the bacteria have combined with the agglutinoid, and cannot, therefore, take up agglutinin.

Agglutinins are relatively highly resistant bodies. They will stand drying for months even when fully exposed to the air. Light has little effect on them, and putrefaction even in a marked degree causes very little loss of agglutinating power. This resistance is in very marked contrast to that possessed by most of the other antibodies produced as a result of bacterial invasion or existing naturally in the serum of an animal. Normal sera often possess agglutinins, which in these cases would be natural. The horse's serum is very rich in them, and will often clump the bacillus of glanders when diluted 300 times, so that when the agglutination test is applied for the diagnosis of this disease this natural antibody is allowed for, and only a horse whose serum, when diluted 500 to 1,000 times, will still agglutinate the glanders bacillus can be considered to be suffering from the disease. Very feeble agglutinating powers have been observed in the serum of young animals, and even fœtal blood has been shown to possess them in some slight degree. Natural agglutinins are probably produced as a result of sub-infection from the intestines, or by mild attacks of disease which pass unnoticed. A fairly strong agglutinating serum has been observed in a three-weeks old calf which was born to a cow which had become infected with the contagious abortion organism, and whose serum would agglutinate it in a dilution of 1:1,000, though the cow did not actually abort. The serum of the calf agglutinated in a dilution of 1:200, the limit of normal agglutination in this disease being put at 1:50. By inoculating an animal with an organism a tremendously powerful agglutinating serum can be produced. Such a serum is produced by

inoculating with gradually increasing doses of the organism at intervals of a week or so for a long period.

Agglutinins are often found in milk and tears, therefore they are probably got rid of in the excretions. Their actual seat of production in the animal body is not yet known, but it has been noted by various observers that they are found at an early date after injection in the lymphoid tissues, such as the spleen. Removal of the spleen, however, does not in any way affect their production, and an extract of leucocytes does not afford any agglutinin at all.

No agglutination of bacteria by a serum will take place in the absence of salts, though combination takes place as with agglutinoid. Sodium chloride is the usual salt used, though other salts may and have been used. Sodium chloride solution in a strength of 0.8 per cent. is always used, as it has been found that this is the amount present in normal serum. Tubercle bacilli in 0.8 per cent. salt solution will occasionally agglutinate spontaneously in the absence of serum, but by reducing the salt content to 0.1 per cent. this can be avoided. Certain non-specific substances such as 1:1,000 corrosive sublimate solution, hydrogen peroxide, various stains, such as fuchsin and safranin, can cause agglutination in an emulsion of bacteria which closely resembles that produced by a serum.

We can now go on to a discussion of the various theories put forward at one time or another to explain the mechanism of agglutination of bacteria. A similar phenomenon may be observed in a suspension of small particles of clay in water to which a little salt is added. The particles run together and commence to sediment, leaving the water clear. The same phenomenon has been put forward to explain the formation of mud-banks at the mouths of rivers, where the fresh and salt water meet. With bacteria, however, agglutination, except in the spontaneous cases previously mentioned, is always a result of the addition to them of an agglutinating serum.

Gruber thought that agglutinin caused the envelopes of the bacteria to become sticky, so that they adhered together. This theory explains why bacteria which have once come in contact with each other stick together, but fails to explain why they approach each other, and also does not take into account the possible fact that the phenomenon is in part physical.

Nicolle thought that the agglutinin precipitated the agglutinable material in the bacteria, causing them to become swollen and viscous in the outer cover, and thus to adhere to each other. This theory is essentially similar to Gruber's, and has the same faults.

Paltauf considered that agglutination of bacteria was due to their being drawn into the interstices of a coagulum. No such coagulum has ever been demonstrated, as it easily could be if present, by staining a preparation of the agglutinated bacteria.

Dineur suggested that agglutination was due to the presence of an adhesive substance on the cilia of the bacteria, causing them to be adherent by the cilia becoming interlaced. This theory presumes that the bacteria are ciliated, and could not explain why non-ciliated bacteria agglutinate.

Bordet's theory, which is the most feasible one which has so far been put forward, explains the phenomenon as being a physical one, the bacteria having only a passive rôle. A point in favour of a passive rôle is that dead bacteria agglutinate just as easily as do living ones. Bordet thought that serum probably acted on bacteria by changing the relations of molecular attraction between the bacteria and the surrounding fluid, thus causing in reality an effect of alteration of surface tension. This theory brings agglutination of bacteria into line with other agglutinations, as of inert particles of clay, etc., but does not in reality, however, explain the intimate character of the reaction, and there must be some previous combination of a biological nature which is not yet understood.

The technique of the agglutination test is quite simple, and to describe it a particular instance will be taken. In, for instance, examining the serum of a cow suspected of being infected with the bacillus of contagious abortion the procedure is as follows:—

One takes an emulsion of the contagious abortion bacillus in 0.8 per cent. saline solution and puts 2 c.c. of it into each of a row of ten small test-tubes of about 4 c.c. capacity. Serum from the suspected cow is then added to each of the test-tubes, so that the first tube contains 1 of serum and 9 of emulsion of bacteria—that is, the serum dilution is 1:10, and then in the other tubes dilutions of serum are made, so that one has a 1:25, 1:50, 1:100, 1:200, 1:400, 1:500, 1:800, 1:1000, and a 1:2000 dilution.

SERUM AND EMULSION OF BACTERIA.

1	2	3	4	5
1:10	1:25	1:50	1:100	1:200
6	7	8	9	10
1:400	1:500	1:800	1:1000	1:2000

The bacterial emulsion must be just faintly turbid, as a thick emulsion is much harder to aggultinate than such a faintly turbid one. It has been found that normal cattle serum may agglutinate the contagious abortion bacillus in a dilution of 1:25 and in rare cases 1:50; therefor in the test, a cow whose serum agglutinates in a dilution of 1:100 or higher is considered infected. The test which has just been described is the macroscopic one, and is always used where the exact agglutinating power of a serum is required to be found. A rough microscopical method may be used where exact results are not required. This method may; for instance, be used in the case

of typhoid fever, when it is simply required to know whether the patient's serum agglutinates the typhoid bacillus, as an aid to clinical diagnosis. In such a case a drop of the patient's serum is mixed with nine drops of an emulsion of typhoid bacilli, and a drop of the mixture is then put on to a cover-slip, which is then inverted over a well in an ordinary slide. The preparation is then incubated for an hour, and examined under the microscope to see whether the bacilli have run into clumps.

In the macroscopic test first described one has always to put up a control row of test-tubes, using in them the same emulsion, but a serum whose agglutinating power on titre, as it is called, is known. The emulsion of contagious abortion bacilli must be from a strain which has been tested at frequent intervals to see if the bacilli agglutinate well. Bacilli from the same stock vary a good deal in sensitiveness to the action of agglutinin. An organism which has been recently isolated does not agglutinate as well as one which has been often subcultured, but, on the other hand, a very old culture loses its sensitiveness. The sensitiveness can be reduced by growing the organism at a temperature above the most suitable one or by growing it in serum from an animal immunised against the disease which it causes.

In concluding the description of the agglutinins and the agglutination test, it may be stated that in present-day research an organism is always subjected to the test when its ultimate proof as the cause of a particular disease is being attempted. In the investigation of a new disease at the present day, should several organisms of different species be isolated from a case of it, the test is particularly useful in deciding whether any one entitled to regard that organism as a very possible cause of the particular disease, and in conjunction with other tests the agglu- one particular species or organism, and not the others, one is tination test may help to establish the identity of the organism of them is the causal agent. If the patient's serum agglutinates as the causal agent beyond doubt. A few species of bacteria do not cause the production of any measurable amount of agglutinin, therefore the absence of the agglutination in the proof of an organism does not mean that it has no connection with the disease in the patient whose serum was used in the test.

Before showing how the agglutination test may be applied in the diagnosis and control of contagious abortion in cattle, a short description of the disease must be given. The disease itself is not fatal, and it is only because of the losses it causes to dairy farmers and cattle breeders that it has become of so much importance. The lesions which are present in a cow suffering from the disease at the time when the calf is about to be prematurely born consist of an exudate between the mucous membrane of the uterus and the outer envelope of the

fœtus, which exudate is thick and creamy in consistence, varying in colour from whitish yellow to brown. The cotyledons of the fœtal envelopes also show alterations, and generally appear yellow and necrotic. These lesions are due to a chronic catarrhal inflammation of the uterus set up by infection with the organism which causes the disease. The fœtus itself shows very few lesions, and may on opening show inflammation of the intestines or a lot of fluid in the abdominal and thoracic cavities. A cow may become infected either by being served by a bull which has become infected from a cow which has recently aborted, or by taking in the organism with food which has got contaminated with the discharges from a cow with the disease. It was found that the serum of an infected cow agglutinated the bacillus which is known to be the causal agent of the disease. The possession of a means of controlling the disease is of the utmost importance when it comes to be considered that such a disease, if allowed to spread, will cause enormous losses to the cattle breeder. In a single herd 80 per cent. of the cows may prematurely calve, and as the calf is nearly always dead, and if not, dies within a few days of birth, the loss can be understood, as, in addition to the loss of the calves, the cows either give no milk or very little. Abortion may occur at any time from the sixth week of gestation to the eighth month. The calf may even be born at the right time and die in a few days, being too weak and sickly to live.

In using the agglutination test as a means of controlling the disease in a herd of cattle, it should be carried out in a very systematic manner. On the suspicion of the presence of contagious abortion in a herd being aroused, as it usually is, by the occurrence of several abortions without any apparent reasons, the serum of every animal, including the bull or bulls, should be subjected to the test. As previously stated in the description of the macroscopic method of doing the test, all sera which agglutinate in a dilution of 1:100 or over should be considered as being from an infected animal, though agglutination at the 1:50 dilution raises suspicion in an infected herd. The sera of cows which have actually aborted usually agglutinate in dilutions of anything from 1:200 to 1:2000, or even higher. Those animals which have given positive results should be isolated from the non-infected ones, and the latter should again be tested after the lapse of about a month, as it has been found that animals very recently infected may not give a positive reaction to the agglutination test, and it has been shown that a cow infected by the mouth artificially will not give a positive reaction for at least two weeks. In a case brought to our notice at the Laboratory, Onderstepoort, a cow was tested and gave an agglutination titre of 1:25, which would would be considered negative. The cow aborted three weeks later, and at the date of abortion the serum agglutinated in a dilution of 1:200, which is a distinctly positive reaction. The agglutination test will not do more than tell

whether a serum is from a cow infected with the specific organism causing contagious abortion in cattle, and the sera of many cows which do not abort give positive reactions even in dilutions of 1:500 to 1:1000. On the other hand, though one cannot predict an abortion, one can say definitely whether a cow which has aborted was suffering from an infection with the organism of contagious abortion or not, and even an isolated case of premature calving in a clean herd should be subjected to the test, as there is always the possibility of its being of a contagious nature, particularly when the cow is a new purchase. As the disease has already been introduced into South Africa, the testing of all fresh cattle introduced into the country would not be very much use now. Cattle which have recently aborted are the most dangerous as sources of infection, and it is a curious fact that the serum of some cows will give a strongly positive agglutination even two years after an abortion, and in some cases after having calved normally in the interval. Whether such cows are a source of infection or not is a debatable point which is being put to the test, and should give interesting results. Such cows must still have the organism in the body, as they would not otherwise go on producing agglutinins. The eradication of the disease is more a problem for individual farmers than for the State. A careful inquiry into the history of any cow bought by a farmer should always be made by him, and should an abortion occur in his herd, the cow should be isolated immediately, and the serum test applied, which it can always be, to any serum sent in by a farmer to a laboratory dealing with diseases of stock. It should not be impossible to gradually rid the country of this disease by a combined effort of farmers with the aid of bacteriological institutions which undertake the agglutination test for the disease, and to limit its spread from farms at present infected should be quite a simple problem.

Portland Cement.—In view of the stoppage of supplies of Portland cement from Germany and Belgium, efforts are being put forth to manufacture this article in other countries on a large scale. Works are being established at Darra, near Brisbane, to produce about 40,000 tons of cement per annum. Electrically-driven grinding mills will be erected, the motors to be three-phase, 50 cycles of 440 volts. In this connection it is interesting to note that the extensive gypsum deposits at Port Nolloth have been acquired by a Natal company, and are now in course of transport to Pretoria for conversion into "Portland cement."

SOUTH AFRICAN HEPATICÆ OR LIVERWORTS.

By Thomas Robertson Sim, F.R.H.S.

The most interesting and the most neglected group of plants in the African flora is the Hepaticæ.

The members of this group are those cellular plants which, together with the mosses, constitute the Bryophyta.

They are distinguished from the mosses by having either spiral elaters or sterile cells present among the spores in the capsule (except Ricciaceæ), and by having only unicellular rhizoids, whereas those of the mosses are many-celled; also by the more delicately cellular nature of their formation, the hyaline and evanescent seta of the capsule, and the formation and dehiscence of the capsule itself.

Many of them have lobed leaves, some have conduplicate leaves, many produce folioles (amphigastria), and some are entirely thalloid, all of which are characters unknown among the mosses; while the usually bilateral arrangement of the leaves, when leaves are present, and the laxly hexagonal areolation, are not common among the mosses.

The sexual arrangements are, however, on the same general lines as those of the mosses, and the alternation of generations is similar, and the power of nonsexual reproduction by means of gemmæ occurs in both, hence the inclusion of both groups in the one class Bryophyta, the Hepaticæ being regarded as the lower and the Musci as the higher group.

The Hepaticæ are of no economic value, and even in the economy of Nature they hold a very unimportant position.

Most of the species are hygrophilous, inhabiting humid forest situations, or the banks of streams, or stones in streams, in some cases under frequent inundation or constant spray. Each species has its own kind of habitat, to which it adheres more or less closely.

But some species, especially in view of their loosely cellular structure, exhibit an extraordinary power of endurance against drought, and habitually occur in sites which are practically dust-dry for many months, where they drag out a flaccid existence during drought, and become fresh and vigorous again as soon as moisture is available. These are, indeed, quite xerophytic species.

Others, especially thalloid forms, under similar dry conditions become more coriaceous in texture, and more or less protected by scales, while in most of the hepatics the protection of the growing point is highly specialised.

The hygrophilous type is probably the older and more normal, the xerophytic types being special adaptations to local circumstances.

The South African species, having to endure extreme drought for many months (sometimes years), even inside the

forests, combined with intense sunshine during summer where not shaded, naturally exhibit extremes of colour and of vigour less frequent in some other lands. A species may be dark brown or almost black on one side of a stone or tree, and bright green or glaucous on the other side, with every gradation between, hence the futility of trusting to colour as a specific character, except in a general way. A species, where loosely attached to a stone or stump, may develop a depauperate condition very unlike an adjoining vigorous patch; or an extension of the patch into dense shade, such as under a stone, may become weak, etiolated, sparse-leaved and flagelliferous; hence the necessity of knowing each plant in nature, under its varying circumstances, rather than accepting a single herbarium scrap as a specific type.

The variation of leaf-form, arrangement, margin, texture and size, and also of the folioles, floral leaves and perianth, even upon a single stem, are often most confusing, and emphasise the necessity of studying many specimens in a tuft before arriving at a conclusion as to the general type-form and the range of its variation, one of the greatest difficulties being that related species frequently range more or less in the same direction, though normally possessed of characters which render them quite distinct.

And perhaps one of the greatest difficulties to the beginner is the frequent intermixture of species, often closely related, which has to be very carefully guarded against in order to avoid confusion.

Some of the thalloid species are annual or usually annual, others are perennial, and in the foliose group I am not aware of any annual species under conditions suitable for prolonged life, but many in that group continue to grow on by means of terminal or lateral innovations, while the older portions die away, and in certain genera it is the habit for mature stems to become prostrate (resembling rhizomes), and to produce adventitious innovations which become new stems, thereby perpetuating the growth from time to time and forming loose cushions.

No true roots occur, but long, one-celled rhizoids take their place, sometimes (among thalloid species) of two distinct kinds, the one large and open, like a vessel in prosenchymatous tissue, and evidently intended for the free flow of sap in quantity, and the other more slender and provided with warty excrescences on the inner surface, which formation is explained to be intended, or at least to act, as an assistance in water-carriage where air is present in the cell, which might otherwise form a full-sized bubble and stop the passage of water, the excrescences holding the bubble in the centre of the tube and allowing water to pass alongside.

Another explanation is that the projecting pegs lead to an increase on the total area of the ectoplastic membrane which lines the protoplasm of the cell inside the cellwall, and is known

to have important functions in connection with the absorption of water and mineral salts.

Be this as it may, these tuberculate rhizoids, though usually produced on the under-surface of the thallus, extend in some cases from the common receptacles of the fructification down special almost enclosed grooves in the peduncle, and along the under-surface of the thallus to the ground-surface—a distance occasionally of two inches—which is held to be a proof that in these cases the peduncle is an adaptation of part of the thallus itself to a special purpose.

In certain amphibious *Ricciæ* rhizoids occur on the land form but not on the floating form, where there is no use for them, and on *R. natans* they are replaced on the floating form by protective flat, serrate scales containing chlorophyll and acting as leaves.

In the case of epiphytic species the rhizoids are sometimes forked and discoid at the end, for the purpose of adhesion.

These rhizoids frequently occur in the most unnatural positions, thus in *Dumortiera*, which grows almost in water, they occur on the under-surface of the stalked common receptacle, and are specially protected in channels sunk into the peduncle down to the ground; in many Lejeuneæ they are grouped on a wart produced on the outer surface of the foliole, and in Radula the rhizoid-producing wart occurs on the infolded lobule of the leaf. The more frequent position, however, is on the under-surface of the stem, either toward its base only, or occasionally along its entire length, and especially in etiolated flagelliferous portions.

The Hepaticæ, having no true roots, are usually epiphytes, and often adhere very tenaciously, by means of the terminal discs of their rhizoids, to mosses, tree-bark, stones, or other hepatics.

They are not known to be parasites, and probably never are so; they are always chlorophyllose, and the chemical salts necessary for their nutriment they are able to absorb directly, with water, over their surfaces, so that the purpose of the rhizoids is, in part at least, the fixation of the plant to its host or site; on the other hand, the greater vigour of an undisturbed patch compared with that of an adjoining patch which has been more or less detached, shows that either the rhizoids absorb, or they keep the plant in such close contact with the host or site as to render absorption easy.

There are certain thalloid genera in which water is not absorbed by the upper surface of the thallus, but rhizoids occur on all parts of its under-surface, connecting with central common strands reaching the ground surface, whereby irrigation of the whole thallus is maintained by the rhizoids and by capillarity between them, apart from the usual osmotic circulation within the plant.

The special contrivances found in this group for the reten-

tion of water supply, and to prevent dying out, are extremely wonderful.

In the thalloid group the mass of overlapping thalli, held in position by rhizoids, is proof against much desiccation; in *Fimbriaria* and some others the under-surface of the thallus, which curves round and comes more or less uppermost when dry, is protected by radiating plates or ridges ending in scale-like appendages, which in youth protect the growing point; in *Metzgeria* and in *Riccia albo-marginata* the margin of the thallus is protected by cellular hairs, which, when dry, lie flat, or fold under the thallus and form water-retainers; in many foliaceous species the leaves are closely imbricated, or even julaceous; some have the leaves finely divided, and when dry curled inwards; in others the two equal lobes of the leaf are more or less closely pressed together and retain water between them; in others, again, the upper lobe is large and complanate, protecting a smaller lobe pressed against its under-surface or concave under it, and so holding moisture. In *Frullania* the smaller lobe is convex toward the other, but is more or less pouched, forming a pitcher protected by the upper lobe; in a few species succulent and almost leafless basal shoots are produced as resting shoots, in others (*Lejeuneae*) resting buds occur as undeveloped lateral branches. In most of the foliaceous species the perianth is more or less tubular and erect; in *Kantia*, which grows on exposed clay banks, it is succulent and pendulous, producing rhizoids, while in *Lindigina* the tuberous downward elongation of the sporogone enters the soil and anchors that portion of the plant, besides producing rhizoids.*

In many species succulent gemmæ are produced, which act as resting buds, or ultimately as detached plantlets; in others the more or less succulent old stem survives and performs the functions of a rhizome; while there are those which produce special rhizomatous branches. In many thalloid kinds a waterproof upper surface protects a succulent formation in which assimilation is performed only by special cells enclosed within protected cavities, and is most of the thalloid, as well as some foliose species, oil is stored abundantly in the cells.

By one or other of all these means, or by other means not detected or not mentioned above, the apparently delicate Hepaticæ survive many climatic vicissitudes.

Strangely enough, a few species are so regularly aquatic in their habits that they have to provide special means of obtaining air, and some which are amphibious undergo modification to suit their environment.

* This peculiar structure has been noted elsewhere, and Prof. Shiv Ram Kashyap, in reference to West Himalayan Liverworts, says: "During the rainy season 4 or 5 inches of rain in 24 hours is not unusual, and occasionally the rainfall may reach 8 to 10 inches. The force of the water on the slopes is naturally very strong, and the plants have to be firmly fixed in order to escape being washed away."—(*New Phytologist*, June-July, 1914, p. 207).

Sexual reproduction is by means of antheridia (male organs) and archegonia (female organs) almost as in the mosses.

The sexual arrangements are found to take four principal forms, *viz.*: *Synoicous,* when the antheridia and archegonia occur mixed together; *monoicous,* when they occur on different parts of the same plant; *dioicous,* when they occur only on different plants; *paroicous,* when the antheridia occur in the axils immediately below the archegonia; but it occasionally happens that more than one of these conditions can be found on the same species.

In the greater number of foliaceous Hepaticæ the fertile inflorescence is at first terminal on a stem or branch, but by the growth of one or two innovations immediately below it, its position often appears a little later to be either lateral or in a dichotomous fork. This constitutes the section *Acrogynæ.*

In the section *Anacrogynæ* it is not terminal, but either on the surface of the stem or thallus, or on short special branchlets.

Among the thalloid Hepaticæ highly specialised modifications of parts of the thallus occur, in some cases as elevated organs acting as common receptacles of the sexual parts; in others, pits are sunk into the thallus itself, in which these sexual organs occur, and it is mostly upon the variations in this respect that systematic arrangement is based.

In addition to sexual reproduction, many species have the power and habit of producing plants from gemmæ, which are adventitious asexual reproductive organs, produced in some cases on the leaf margin, in others on a special discoid stem-apex, and in the thalloid genera in special gemmæ cups. This means of reproduction is frequent in certain species, and is altogether absent in others.

In some species it occurs usually on sterile parts or plants; in others this is not so, but its effectiveness is seen in *Lunularia,* apparently an important plant to South Africa, in which sexual reproduction has not been observed here, though its reproduction by gemmæ and distribution with greenhouse plants has carried it to many localities, and the same has happened to it in Northern Europe, its home being the Mediterranean region.

Goebel goes so far as to say: "I have been led by my investigations to the view that every cell in the Hepaticæ has the latent capacity to develop further, like the spore, but this is only called forth if there is an enfeeblement of the vegetative body."*

Certain species have also an abnormal multiplication of parts, a sort of crested or double condition which seems to be vegetative only. This occurs in *Anthoceros, Fossombronia, Aneura,* and possibly others.

In most of the foliose Hepaticæ the leaves are alternate and complanate, *i.e.,* flat in two rows, though the mode of attach-

* Goebel, "Organography of Plants," (1905) 2, 52.

ment varies considerably. But in many cases there is a third row, consisting of small leaves (folioles) placed on the under-surface of the stem, nearly opposite every second leaf, thus completing a normal tristichous leaf-arrangement, although species occur in which these are irregularly present, and this sometimes happens in regard to different branches of one plant.

These folioles, characteristic of many Hepaticæ, are present in very few cases among the mosses.

The hepatic capsule is usually a tender hyaline structure, which at maturity bursts almost or quite to the base, either irregularly or into four or eight valves, in which latter case it somewhat resembles that of the Andreæaceæ among the mosses; indeed, in the earlier systematic works, the species of Andreæa were included in the hepatic genus Jungermannia.

But the Hepaticæ have a hyaline seta also (when a seta is present), and have the habit of retaining the capsule in the perianth till the spores are mature, at which stage the delicate seta develops rapidly—often in one day—to its full length, which may be up to an inch or more; then the capsule bursts, disperses its spores, and then disappears as rapidly as it arrived.

In view of this being the usual case in nature, it is worthy of mention that in carefully dried specimens the burst capsules are as easily preserved as the foliage, and I have many South African specimens 25 years old, and some European specimens 50 years old, in which the burst capsules, as well as the spores and elaters, are in good form, and as fit for examination to-day as when alive.

I have already referred to the spiral elaters found in the capsule among the spores, and would only add that either these elaters, or in the lower forms sterile cells, are present in every case in the Hepaticæ except Riccia, and never in the mosses.

In their early stages they are shortly cylindrical cells, often loose, in each of which either one or two spiral bands are closely coiled.

Before maturity of the spores the cell-wall of the elater entirely breaks down, releasing the coil, which lengthens out, but still retains its spiral or two-spiral form, these respective conditions holding good through large orders, which are evidently homogeneous, quite apart from this minute character.

The function of the elater is still undecided, some claiming that its contents aid the nutrition of the young spores; others that it aids spore distribution. Probably it has its use in both these directions.

What has been said so far has been culled from South African examples, though, of course, much of it applies to Hepaticæ in general.

But in regard to the Hepaticæ of South Africa it may be further stated that the list attached hereto shows that the local flora is fairly representative of the Hepatic flora of the whole world. In a general way it may be said that almost all the

South African genera are widely distributed in similar climates; also that most of the genera found in similar climates elsewhere are represented in South Africa, though there are a few exceptions both ways, mostly in exceedingly local or monotypic genera.

There are tropical genera which have not yet been recorded, but our tropical regions have not yet been well explored in this connection. There is also a scarcity of certain conduplicate-leaved cold-region forms (Scapania, Lophozia, etc.), which may also to some extent be removed when the mountain streams of the Drakensberg are further explored.

But there is no distinctively South African group, such as occurs among the Phanerogams (Protea, Restio, Erica, Mezembryanthemum, etc.), the nearest approach being the tendency toward a succulent sporogonium found in several genera; also the 27 species of Lejeuneaceæ may be compared with the absence of that Family California.*

In regard to the distribution of genera, one has to consider along with that the limitations of these genera, on which point opinions still vary considerably, and may do so for ages.

But in regard to species, although many are of wide range, a very considerable number of the names on the list represent what are regarded as South African endemic species, though closely related and sometimes almost identical with species which occur elsewhere.

On this point Spruce, after describing minute characters wherein one South African plant differs from its European relative, very appropriately says: "Now the question is, are these differences to be accounted specific or merely varietal? The same question recurs almost whenever a European species reappears in South America and Africa, for the coincidence of structure is scarcely ever exact, and although we are sure that these analogous forms have had a common ancestor at no very remote period, we find it difficult to so bridge over the oceanic interval as to account for the very wide dispersion."†

C. F. Austin, in dealing with the forms of a certain moss, says: "These forms clearly depend upon external causes—as matrix and climate—for the development of their peculiarities; in fact, so far as I have observed, *there is no such thing as variety among any of the Cryptogams* in the sense in which the term variety is applied to Phanerogams; none of them having the power to reproduce their peculiarities under a change of matrix, or of climatic influence." ‡

Particularly in regard to colour and vigour, on which many so-called species have been founded, does this hold good. If Austin's view is accepted, then we have local *conditional forms*, subject to circumstances which may or may not be of a per-

* "The Hepaticæ and Anthocerotes of California," by M. A. Howe, 1899.

† Spruce, in Pearson, *Hepaticæ Natalensis*, (1886) 10.

‡ *Bot. Gazette*, October 1877, page 143.

manent or general nature, rather than varieties, and it is quite probable that some local so-called *endemic species* come under that head.

As some of the South African species are known to also occur in India, China, Japan, Java, Australia, North, South, and Central America, West Indies, and many oceanic islands, as well as in Europe and in other parts of Africa, there would be little reason for surprise if others, now regarded as South African only, prove eventually, when better known to a larger circle, to be also represented elsewhere; nor is there any reason for surprise if many further foreign species be still found in South Africa, where so many different climatic conditions occur.

And it must be remembered that in many cases a herbarium expert deals with a specimen, or even a scrap, rather than a species, and would give a different verdict if he could combine abundant field work, in many countries, with his microscopic study. It is evident that the main groups and even the larger genera are practically cosmopolitan, a proof either that these types are very primitive or that their trans-oceanic distribution is more easily accomplished than is that of Phanerogams. How that distribution occurs has not been proved, but it seems probable that the spiral elaters may be at least one factor, since the spores often adhere to the elater, which may act as a float in long-distance wind currents. If this be so, it indicates extraordinary endurance on the part of the spore—an endurance also exhibited against extreme cold in arctic and antarctic regions, and against extreme drought in desert regions—and it also points to a use for the papillæ which cover the spores of many species.

It is believed that the Hepticæ are a very primitive group, but if the world-wide distribution dates back to remote ages, under different geographical and climatic conditions, then one would expect more pronounced local specific and even generic variation than actually occurs, were it not that the environment has remained more or less the same, being a water environment.

A good many species have identical characters in all parts of the world: are these fixed types which have remained unbroken through countless ages, or are they more recent types, possessed of long endurance in the spore condition and well-developed though still undetected or unproved powers of transportation?

Strong arguments may be produced in favour of either view; for the former is the fact that the same cosmopolitan character is seen among the green fresh-water Algæ, and these could not have been distributed by wind or even by salt water; for the latter view is the fact that some of these world-wide species are ubiquitous where conditions are favourable, occurring even in remote oceanic islands and in spots far distant from the nearest locality suitable for and inhabited by the same class

of Hepatics, a circumstance which, so far as we know, could only occur through wind transportation and the continual free distribution of spores, even at the cost of very many lost through failure to find a suitable nidus.

But the subject of trans-oceanic migration is further complicated by the fact that while the more or less xerophilous forms usually have small spores, destitute of chlorophyll but possessed of a special protective covering, often papillose and sometimes more or less ribbed, there are other Hepatics, especially those of hygrophilous nature, whose spores are thin-walled and chlorophyllose, and usually germinate as soon as mature, sometimes even before they are shed from the parent plant, and still some of these are widely distributed.

Wide exotic distribution is, however, more frequently the case with aquatic or amphibious plants, even in the higher Phanerogamic orders, than it is among other and particularly xerophytic plants.

In connection with this and with the whole question of evolution of mosses and Hepaticæ from a common source, Goebel sums up the matter thus:*—From the varying vegetative organs "we gain the impression that the *Hepaticæ,* apart from the *Anthoceroteæ,* are a younger group, still in a condition of flux as compared with the older more fixed Musci," but the structure of the sexual organs "appears to be an inherited portion from common ancestors. In other words, if we assume a descent in general, it follows that the vegetative organs must have been greatly changed in different directions, while the sexual organs have altered but little."

South Africa was early in the field in regard to the study of Hepticæ, for while Linnæus, in his "Species Plantarum" (1764), had only 28 species from the whole world, Thunberg added some from South Africa in his "Prodomus Floræ Capensis" (1794-1800).

During the first half of the nineteenth century further specimens were collected in South Africa, mostly near Capetown, by Bergius, Breutel, Menzies, Mund, Ecklon, Drège, Krauss, Gueinzius, and Dr. Pappe, which were sent to Europe and classified and described by experts there in many publications and under many synonyms.

Chaos was reduced into order by the publication in 1845-1847 of Gottsche, Lindenburg and Nees' "Synopsis Hepaticarum," in which the Hepaticæ of the world, as then known, were dealt with, and that work still holds an honoured place, and is indispensable to the student of South African Hepaticæ.

More recent collectors include Rev. A. E. Eaton (Cape), Iverson (Knysna), Bertelsen (Natal), Rehmann, Dr. Wilms, MacLea, Bachmann, etc., whose specimens have been dealt with and new ones described, by Mitten, Pearson, Schiffner, and Stephani; Cavers recently described the interesting *Riella*

* Goebel, "Organography of Plants," (1905) **2**, 8.

capensis from Port Elizabeth, and among present-day collectors are Professor Pearson, Sc.D., Mr. Pole Evans, Miss Pegler, Professor Bews, D.Sc., Mr. A. Reid, and Mr. Burtt-Davy.

The literature dealing entirely or in part with, or having an equally important bearing on, South African species from a systematic standpoint, forms a very long list, mostly in Latin, French, or German, and is very scattered and difficult to obtain or even consult in South Africa.

No monograph of the South African species has yet appeared, and even in regard to South African genera only two synoptical lists have appeared, *viz.*: (1) that in Harvey's "Genera of South African Plants," first edition (1838), in which five genera are given; and (2) that by Diels in Marloth's "Flora of South Africa" (1913), in which 39 genera are given, said by Stephani to include 104 South African species.

But in regard to the structure and relationships of the Bryophyta (including South African Hepaticæ) three recent works stand out pre-eminently, *viz.*, "Mosses and Ferns," by Campbell (1895); "Organography of Plants," Part II (1905), by Goebel; and "The Interrelationships of the Bryophyta," by Cavers (1911).

In dealing with the South African Hepaticæ, it is also necessary to keep in view the enormous amount of systematic work done by European botanists upon Hepaticæ from Central Africa, Madagascar, and the Mascarenes, published also in exceedingly scattered form, since the floras of these localities and of South Africa overlap in regard to every large group, and probably also in regard to species, to a greater extent than is yet known.

Through the great kindness of almost every botanist in South Africa and several elsewhere, I have been able to consult much of the literature mentioned above, and the list attached hereto represents the records and specimens which have come under my notice, boiled down in so far as synonymy is concerned as far as present information will allow. These and all further materials are being used in the preparation I have in hand of a "Handbook of South African Bryophyta," for which purpose I invite the aid of every collector, in the form of specimens from his own district, of mosses and Hepaticæ, however common. The common species of one district are often the rare species in another district, and it is only by collating specimens from many collectors and from many localities that the distribution of each species can be decided.

In my own herbarium, collected throughout South Africa during the past 26 years, I find specimens of most of those recorded by others, as well as additional species, and have no doubt but that many further species still remain undetected, especially in the Northern portions of our area. Every collector consequently stands a fair chance of sending in new species, besides extending our knowledge of the distribution and local variation of species.

The Hepaticæ known meantime are about as under:—

	Genera.	Species.
Whole World	250	4,500
Britain (Macvicar's Handbook, 1912)	73	274
Madagascar and Mascarenes (Renauld's "Flore Bryologique"), 35 genera and 22 sub-genera of Lejeunea, treated above as genera	57	222
South Africa, as per this list, 47 genera and 12 sub-genera of Lejeunea, treated above as genera	59	163

So, unless South Africa is proportionately very low in species, many more still remain to be discovered, and it is quite probable that some included in the present list will still prove to be synonyms.

Explanation of Unusual Technical Terms used in Following List:

Incubous, *leaves overlap upward on front of stem.*
Succubous, *leaves overlap downward on front of the stem.*
Folioles, *amphigastria or underleaves: the small leaves on underside of stem forming the third row.*
Lobule, *the smaller lobe of a two-lobed leaf.*
Marsupium, *a specially-developed tube, often succulent and conglomerate, surrounding the sporogonium.*

SYNOPTICAL LIST.

Order I. SPHÆROCARPALES.

Sexual organs superficial and almost sessile, but each separately enclosed in a special envelope developed from the thallus, and extending beyond the enclosed organ. Sterile cells are mixed among the spores, but no spiral elaters; the capsule is single-layered, without fibrous thickenings, and bursts irregularly. Usually thalloid with no air-chambers in the thallus, but with or without leaves in addition. Rhizoids smooth.

Family 1. Riellaceæ. Stem erect with one undulate one-layered dorsal thalloid expansion, and sometimes also provided with small leaves from each side of the stem. Archegonia in flask-like envelopes on the stem along the base of the wing; antheridia on the free edge of the wing enclosed separately in specially thickened portions of the wing.

Genus 1. **Riella**. Characters as above. Aquatic, submerged.
1. R. capensis. Cav. Port Elizabeth.

Order II. MARCHANTIALES.

Thalloid, the thallus usually differentiated into (1) a hyaline epidermis; (2) an upper zone of green tissue, with or without air-chambers; (3) a lower zone of large-celled hyaline tissue. Pores from the air-chambers usually present in the

upper surface; lunate scales or ridges often present in rows on the under-surface, each usually bearing at first an appendage, which in its youngest stage folds over and protects the growing point, which consists of a group of initial cells. Smooth and tuberculate rhizoids usually both present. Sexual organs either embedded separately in the thallus or collected into groups (special receptacles), which are either sessile or more or less pedunculate. No columella present.

Family 2. RICCIACEÆ. Antheridia and archegonia immersed singly in cavities of the upper surface of the thallus. Sterile cells not present among the spores.

Genus 2. **Riccia.** Small terrestrial or aquatic thalloid plants.

2. R. albomarginata Besch.
3. R. bullosa Link.
4. R. concava Besch.
5. R. fluitans Linn. = *Ricciella.*
5b. R. fluitans Linn. *var.* angustifolia.
6. R. limbata Besch.
7. R. natans Linn. = *Ricciocarpus.*
8. R. purpurascens L. & L. = *Ricciella.*
9. R. sp.

Family 3. TARGIONIACEÆ. Archegonial group terminal, sessile, enclosed in two scales; antheridia on special short branches. Elaters 2-3-spiral.

Genus 3. **Targionia.** Small thalloid plants, on alluvial soil.

10. T. capensis Hüb.

Family 4. MARCHANTIACEÆ. Antheridia and archegonia in separate groups; archegonial groups placed on peduncled receptacles; sterile cells (usually spiral elaters) present among the spores.

Section 1. OPERCULATAE. Capsule dehiscing irregularly, or by its lid becoming detached in one piece.

Sub-section 1. Carpocephala dorsal, produced in succession on the thallus surface, the peduncle not grooved or furrowed.

Genus 4. **Plagiochasma.** Involucres 1 to 4, with one archegonium in each, and erect through absence of dorsal tissue on the receptacle.

11. P. sp. Rhodesia.

Sub-section 2. Carpocephalum terminal, its peduncle grooved (except *Lunularia*). Involucres horizontal or pendent, often containing more than one archegonium.

Genus 5. **Reboulia.** Capsule cap falling away in fragments. Perianth none.

12. R. hemispherica Raddi. = *Marchantia hemispherica Linn.*
Asterella hemispherica P. de B.

Genus 6. **Grimaldia.** Capsule cap separating as a distinct lid. Perianth none.

13. G. sp.

Genus 7. **Fimbriaria.** Special perianth present, consisting of many membranous segments, permanently protruding from the involucre.

14. F. Bachmannii St. Pondoland.
15. F. marginata Nees. Common.
16. F. muscicola St.
17. F. Wilmsii St.

Section 2. COMPOSITAE. Each involucre contains a group of archegonia. Capsule splitting into 4 to 8 teeth.

Genus 8. **Lumularia.** Peduncle of receptacle not grooved. Antheridia clusters sessile; antheridia stalked. Gemmæ-cups crescent shaped.

18. L. cruciata (Linn.) Dum. = *Marchantia cruciata Linn.*
    Lunularia vulgaris Mich. Exotic? usually in greenhouses or verandahs. Not seen fertile in South Africa.

Genus 9. **Dumortiera.** Peduncle 2-grooved, air chambers and pores usually absent; antheridiophores nearly sessile. No gemmæ-cups, or gemmæ.

19. D. hirsuta (Sw.) R. Bl. & N. =*Marchantia hirsuta Sw.;*
    D. irrigua R. Bl. & N.; D. hirsuta var irrigua Spruce. Frequent in forest streams.

Genus 10. **Marchantia.** Peduncle 2-grooved; air-chambers and pores conspicuous; antheridiophore pedunculate. Gemmæ-cups round.

20. M. Berteroana L. & L.
21. M. tabularis Nees. = *polymorpha L. & L. (not Linn.).*
22. M. Wilmsii St.
23. M. polymorpha Linn.

Order III. JUNGERMANNIALES.

Plant foliose in most cases, thalloid in some; when thalloid the thallus is not differentiated into layers of different tissue, and is without pores. Tubercular rhizoids not present. Sexual organs usually in groups, but not on special pedunculate receptacles, and seldom immersed. Capsule, which is usually on a long seta, is destitute of lid, opens by 4 valves, and contains spiral elaters as well as spores. Apical growth of stem or thallus proceeds from a single apical cell.

Sub-order 1. ANACROGYNÆ. Archegonia on the upper surface, not terminal; involucre of sexual organs consequently not representing leaves.

Family 5. ANEURACEÆ. Plant thalloid. Sexual organs from marginal or ventral branchlets. Elaters unispiral. Elaterophores remain as tufts on the apex of the capsule valves.

Genus 11. **Aneura.** Sexual organs from short lateral marginal branches. Capsule ovoid. Thallus often without midrib.

24. A. compacta St.
25. A. fastigiata L & L. = *Jung. fastigiata L. & L.; Riccardia fastigiata (L. & L.) Pears.*
26. A. multifida (Linn.) Dum. = *Jung. multifida Linn. Riccardia multifida Gray.*
27. A pinnatifida Nees.

Genus 12. **Metzgeria.** Sexual organs on branchlets from the midrib on the under surface. Capsule spherical.

28. M. furcata (Linn.) Dum. = *Jung. furcata Linn.*
29. M. nudifrons St.

Family 6. BLYTTIACEÆ. Plant thalloid; sexual organs from the upper surface, not marginal; capsule ovoid; elaters 2-spiral; elaterophores absent. Ring-fibres absent from cells of capsule wall; dehiscence of capsule valves incomplete.

Genus 13. **Blyttia.** Perianth present; calyptra thin. Grows on moist soil.

30. B. Stephani (Jack). = *Pallavicinia Stephani Jack.*
31. B. Lyellii G. L. & N. = *Jung. Lyellii Hk.; Pallavicinia Lyellii Gray; Dilæna Lyellii Dum.* Common.

Genus 14. **Symphogyna.** Perianth absent, calyptra succulent, bearing the archegonia on its upper portion. Grows on moist soil.

32. S. Harveyana Tayl.
33. S. Lehmanniana M. & N. = *Jung. Lehmanniana Mont.*
    Jung. Lyellii L. & L.
34. S. podophylla M. & N. = *Jung. podophylla Thun.*
35. S. rhizoloba Nees. = *Jung. rhizoloba Schw.*

Family 7. CODONIACEÆ. Plant with stem and leaves. Capsule globose.

Genus 15. **Fossombronia.** Folioles absent. Rhizoids purple. Frequent on moist soil in shade.

36. F. crispa Nees. = *Jung. pusilla Lehm.*
37. F. leucoxantha L. & L. = *Jung. leucoxantha L. & L.*
38. F. pusilla (Linn.) Dum. = *Jung. pusilla Linn.*
39. F. tumida Mitt.

Sub-order 2. ACROGYNÆ. Archegonia terminal on stem or branch, the involucre (perianth) representing true leaves. Antheridia borne in axils of more or less modified leaves. Stem always producing two lateral rows of leaves, and an additional row of small leaves (= folioles or amphigastria) is often present on the lower surface.

Tribe 1. JUBULOIDEÆ. Elaters few, with only one spiral fibre, and fixed by one end to the capsule-wall, and pendent, extending to the base of the capsule-cavity. Archegonia usually

1 to 4. Leaves incubous, usually complicate—2-lobed, the lower lobe (*lobule*) small. Folioles usually present; perianth usually ridged, and contracted above to a narrow mouth till burst by the capsule. Seta short; capsule globose, the lower part solid.

Family 8. FRULLANIACEÆ. Branches intra-axillary; innovations rarely present. Archegonia usually 2 or few in a group. Lobule convex toward the upper lobe, and usually pouched, galeate, lunate, cylindrical or crested, with a short attachment to the larger lobe, and separate from the stem, a small subulate process being usually present between.

Genus 16. **Frullania.** Characters of the family. Usually epiphytic.

40. F. apiculata Nees. = *Jung. apiculata Hep. Jav.*
41. F. brunnea Spreng. = *Jung. brunnea Spreng.*
42. F. caffraria St.
43. F. capensis G.
44. F. diptera Nees. = *Jung. diptera L. & L.*
45. F. Ecklonii (Spreng.) L. & L.; = *Jung. Ecklonii Spreng; Jung. arecæ Spreng.; Fr. Mundtiana L. & L.*
46. F. Lindenbergii G.
47. F. squarrosa L. & G. = *Jung. tuberculata L. & L.*
48. F. serrata G.
49. F. trinervis L. & G.; = *Jung. lobulata Spreng.; Jung. dillatata L. & L.; Jung. obscura L. & L.*

49,3. F. trinervis L. & G. *var* elongata = *Jung. elongata L. & L.*

50. F. tamarisci (Linn.) Dum. = *Jung. tamarisci Linn.; Jubula tamarisci Dum.*

Family 9. LEJEUNEACEÆ. Branches infra-axillary; innovations usually present immediately below the female inflorescence, which is monogynous. Lobule usually present, concave toward the upper lobe, or flat, usually with a long attachment, and often attached to the stem also; sometimes the lobule is absent or only the lower margin inflexed. Capsule wall of 2 layers, the inner thickened irregularly. Usually epiphytic.

Genus 17. **Lejeunea.** Involucral leaves like the others; lobule of leaf various. (The sub-genera given below are often treated as genera, and may be so by me in future.)

§ *Acrolejeunea.*

51. L. cucullata Nees.
52. L. Pappeana Nees. = *Omphalanthus Pappeana H. & N.; Phragmicoma Pappeana Nees.*

§ *Anomalolejeunea.*

53. L. pluriplicata Pears. = *Anom. pluriplicata Spruce.*

§ *Archilejeunea.*

54. L. chrysophylla L. & L. = *Jung. chrysophylla Lehm.*

55. L. rotundistipula Ldbg. = *Jung. rotundistipula Ldbg.*
56. L. unciloba Ldbg.
57. L. xanthocarpa L. & L. = *Jung. xanthocarpa L. & L.*

§ *Cololejeunea.*

58. L. minutissima Dum = *Cololej. minutissima (Dum) St.*

§ *Diplasiolejeunea.*

59. L. Kraussiana Ldbg. = *Diplasiolej. Kraussiana (Ldbg.) St.*

§ *Drepanolejeunea.*

60. L. hamatifolia Dum. = *Jung. hamatifolia Hook. Drepanolejeunea hamatifolia (Dum.) St.*

§ *Euosmolejeunea.*

61. L. trifaria Nees (including L. rufescens Ldbg.) = *Euosmolejeunea rufescens (Ldbg.) St.*

§ *Eulejeunea.*

62. L. Breutelii St.
63. L. caespitosa Ldbg.
64. L. capensis G.
65. L. cavifolia (Ehrh) Ldbg. = *Jung. serpyllifolia Dicks.*
Lejeunea serpyllifolia Lib.
66. L. Ecklonii Ldbg.; = *Jung. serpyllifolia L. & L.*
67. L. flava Sw. = *Jung. flava Sw.*
67β. L. flava Sw. *var* convexiuscula Pears.
68. L. laeta L. & L.
69. L. isomorpha (G.) = *Eulejeunea isomorpha G.*
70. L. tabularis (Spreng.) L. & G. = *Jung. tabularis Spreng.*
71. L. Wilmsii (Step.) = *Eulejeunea Wilmsii St.*

§ *Microlejeunea.*

72. L. gracillima Mitt.
73. L. Helenæ Pears.

§ *Ptycholejeunea.*

74. L. striata L. &. L. = *Ptychanthus squarrosus Lehm.*

§ *Strepsilejeunea.*

75. L. krakakammæ Ldbg.

§ *Taxilejeunea.*

76. L. vallis-gratiæ St.

Genus 18. **Thysanthus.** Involucral leaves two, different from the others, unequally 2-lobed. Lower margin of leaf inflexed.

77. T. africanus St.

Tribe II. JUNGERMANNIÆ. Elaters many, variously arranged but never as in *Jubuloideæ*. Elaters with 2 or more spiral fibres in each. Archegonia usually numerous in a group.

always more than four. Leaves various; perianth often not ridged; seta long; capsule 4-valved, bursting to the base.

Family 10. PORELLACEÆ. Leaves incubous, complicate-2-lobed, the lower lobe the smaller. Capsule wall of 2 layers, the inner thickened irregularly. Folioles present. Perianths terminal on short lateral branches, free.

Genus 19. **Madotheca.** Characters of the family. Both epiphytic and on soil.

78. M. capensis G. = *Porella capensis Mitt.*

79. M. sp.

80. M. sp.

Family 11. RADULACEÆ. Leaves incubous, complicate-2-lobed, the lower lobe the smaller. Capsule-wall of two layers, the inner thickened irregularly. Folioles absent. Perianth usually terminal on the stem, compressed, free. Rhizoids often produced from a wart on the lobule..

Genus 20. **Radula.** Characters of the family. Epiphytic or on wet mud.

81. R. aquilegia Tayl. = *R. physoloba Mont.*

82. R. capensis St.

83. R. complanata Dum. = *Jung. complanata Linn. Jubula complanata Corda.*

84. R. Lindbergii G. = *R. commutata G.*

Family 12. SCAPANIACEÆ. Leaves transverse or succubous, complicate-2-lobed, the upper lobe the smaller, or the lobes nearly equal. Folioles often present.

Genus 21. **Schistochila.** Perianth connate with the calyptra into an erect fleshy marsupium. Rhizoids red. Foliole bifid and toothed.

85. S. alata (Nees) = *Gottschea alata Nees.*

Family 13. PTILIDIACEÆ. Ieaves either incubous or almost transversely inserted, deeply cut into two or more segments, not conduplicate; folioles present, similar and almost as large. Involucral leaves polyphyllous. Perianth plaited at the mouth, often concrescent with the involucre.

Genus 22. **Chanondanthus.** Inflorescence terminal. Leaves deeply several-lobed, dentate at base; folioles similar and about as large, but 2-lobed.

86. C. hirtellus (Web.) Mitt. = *Jung. hirtella Web. Jung. fimbriata Rich.*

Genus 23. **Anthelia.** Inflorescence terminal on stem and branches, leaves imbricate, keeled, with 2 equal acute lobes; folioles similar. Involucral bracts adnate to the base of the perianth.

87. A. africana St.

Genus 24. **Herberta.** Inflorescence terminal; leaves secund, deeply 2-lobed; lobes long and narrow with a central band of long cells resembling a midrib. Perianth free but nearly concealed among bracts.

88. H ochroleuca (Spreng.) = *Jung. ochroleuca Spreng.*;

Sendtnera ochroleuca Nees; Leproma ochroleuca Spreng.;
Jung. hirsuta Nees; Schisma ochroleuca Dum.

Genus 25. **Lepicolea.** Inflorescence cladogynous (*i.e.*, on short lateral branchlets).

89. L. sp.

Family 14. CEPHALOZIACEÆ. Leaves not complicate, usually cut into two or occasionally several segments, in some species entire; folioles usually present. Perianth sometimes cylindrical, more usually triangular in cross section with one side of the triangle on the upper surface. Female inflorescence usually on short branches from the lower surface.

§ 1 Leaves rounded, succubous; margin entire or toothed.

Genus 26. **Odontoschisma.** Leaves entire, obliquely inserted; folioles small and subulate, or absent. On clay banks.

90. O. denudatum (Nees) Dum. = *Jung. denudatum Nees; Cephalozia denudata Mart; Sphagnocetes communis Nees, var macrior Nees.*

Genus 27. **Adelanthus.** Leaves transversely inserted, more or less secundly bent downward, the upper margin entire and incurved, the lower margin dentate. Folioles absent or rudimentary. Stem ascending, not rooting. Marsupium short.

Genus 28. **Alobiella.** Leaves entire or bidentate; stem prostrate, rooting.

93. A. sp.

§ 2. Leaves incubous, entire or 2-3 dentate. On soil or among mosses.

Genus 29. **Kantia.** Leaves entire or bidentate; folioles present; often bifid or emarginate; marsupium tubular, fleshy, pendulous, investing the mature sporogonium.

94. K. arguta Ldbg. = *Calypogeia arguta N. & M.*

95. K. bidentula (Web) Pears. = *Calypogeia bidentula Nees; Cincinnulus bidentula (Web) St.*

96. K. fusca (L. & L.) Steph. = *Jung. fusca L. & L., Lejeunea fusca L. & L.*

97. K. sphagnicola Arn. & Pers.; = *Calypogeia sphagnicola W. & L.; Calypogeia trichomanis var sphanicola Meylan.*

98. K. trichomanis Lindb. = *Mnium trichomanis Linn., p.p.; Calypogeia trichomanis Corda; C. fissa var integrifolia Raddi; Cincinnulus trichomanis var communis Boulay.*

Genus 30. **Bazzania.** Leaves oblique, from a wide base, narrowed to a rounded or 3-toothed apex. Folioles present.

99. B. convexa (Thun) Mitt. = *Jung. convexa Thun; Jung. Thunbergii Meisn.; Jung. nitida Web.; Mastigobryum convexum Ldbg.; Pleuroschisma convexa Steph.*

100. B. exile (Lindbg.) = *Mastigobryum exile Ldbg.*

§3. Leaves 2-lobed, succubous.

Genus 31. **Cephalozia.** Leaves flat or somewhat concave, obliquely inserted. Small tender plants, on soil or among mosses.

101. C. bicuspidata (Linn.) Spruce; *Jung. bicuspidata Linn.*
102. C. connivens (Dicks) Ldbg. = *Jung. bicuspidata Dicks; Ceph. multiflora Ldbg.*

102β. C. communis var flagellifera Pears.

103. C. divaricata (sm) Spr. = *Jung. divaricata Eng. Bot.*
104. C. heteromorpha (Lehm) Pears. = *Jung. heteromorpha L. & L.*
105. C. Kiaeri (Aust) — *Jung. Kiaeri Austin.*
106. C. tenuissima Lehm. = *Jungermannia tenuissima L. & L.*

Genus 32. **Nowellia.** Leaves transversely inserted, very concave, 2-lobed, the lobes with long filiform points consisting of one row of cells; the leaf-margin on the under side of the stem inflexed and saccate, forming a lobule in an unusual position.

107. N. curvifolia (Dicks.) Mitt. = *Jung. curvifolia Dicks.; Cephalozia curvifolia Dum.; Jung. Baueri Mart.*

§ 4. Leaves deeply cut into two or several segments. Usually on soil.

Genus 33. **Lepidozia.** Leaves incubous, oblique, deeply cut into 2 to 6 long narrow segments. Folioles similar but smaller.

108. L. bicruris St.
109. L. capillaris Ldbg. =*Jung. capillaris Ldbg.; Jung. hippurioides Tayl.*

109β. L. capillaris Ldbg. var minor.

110. L. chætophylla Spr. = *Cephalozia nematodes (G.) Aust.; Jung. nematodes G.*

110β. L. chætophylla Spr. var tenuis Pears.

111. L. lævifolia Nees. = *Jung. lævifolia Tayl.*
112. L. setacea (Web.) Mitt. = *Jung. setacea Web. Blepharostoma setaceum Dum.*
113. L. truncatella Nees. = *Jung. cupressina Lehm. Jung. cupressina Lehm. var capensis L. & L.*

113β. L. truncatella Nees var minor.

Genus 34. **Psiloclada.** Leaves succubous, 3-5 partite.

114. P. sp.

Family 15. Lophoziaceæ. Leaves succubous or transversely inserted (not incubous), entire or dentate or 2-lobed. Folioles absent or rudimentary. Perianth when present either laterally compressed, cylindrical or ovate, or if triangular in cross section having one side of the triangle on the lower surface. Infloresence usually terminal on stem or larger branches, except in Chiloscyphus.

§ 1. Leaves entire or slightly emarginate, succubous, alternate except in *Lindigina*.

Genus 35. **Jamesoniella.** Leaves entire, semi-amplexicaul, decurrent, those on either side of the stem pressed face to face. Folioles absent except in the involucre. Involucral leaves somewhat laciniate. Perianth free, terete-plicate, contracted at the mouth.

115. I. colorata (Spr.) Schiffn.; = *Jung. colorata Lehm.*

116. I. sp.

Genus 36. **Aplozia.** Leaves entire, hardly decurrent; folioles absent or minute. Perianth free or almost free, terete-plicate, contracted at the mouth. Involucral leaves similar to the stem leaves but larger.

117. A. Rehmannii (St.) = *Jung. Rehmannii St.*

118. A. cæspiticia (Ldbg.) Dum. = *Jung. cæspiticia Ldbg.; Solenostoma cæspiticia St.*

Genus 37. **Notoscyphus.** Leaves entire, not decurrent, the cells containing oil bodies. Folioles present, lanceolate, subulate or bifid. Perianth included in and concrete with the involucral bracts and the hollowed out stem-apex, forming an erect succulent marsupium, sometimes having a succulent bulb at the base. Rhizoids white.

119. N. lutescens (L. & L.) Mitt. = *Jung. lutescens L. & L.; Gymnomitrium lutescens G.L.N.*

120. N. variifolius Mitt.

121. N. vermicularis (L. & L.) = *Alicularia vermicularis L. & L.*

122. N. flexuosa (Nees), = *Alicularia flexuosa Nees.*

Genus 38. **Nardia.** As in Notoscyphus except:—Rhizoids purple; folioles minute or absent, when present bifid.

123. N. Jackii St.

124. N. stolonifera St.

Genus 39. **Lindigina.** Leaves entire opposite, somewhat connate at the base, closely imbricated; folioles absent. Marsupium succulent, long, descending into the soil. (*Gongylanthus in Marloth's Flora of S. Afr.*)

125. L. prostrata G.

126. L. renifolia Mitt.

127. L. scariosa (Lehm.) Mitt. = *Jung. scariosa Lehm.; Gymnomitrium scariosum Nees.*

Genus 40. **Chiloscyphus.** Leaves quadrate, entire or slightly emarginate. Folioles bifid, segments often with a lateral tooth. Inflorescence on short lateral branches. Perianth campanulate with wide 3-lobed mouth.

(*Not well distinguished from Lophocolea.*)

128. C. expansus Nees = *Jung. expansus Lehm.; Lophocolea expansa Nees.*

129. C. fasciculatus L. & G. = *Jung. fasciculatus Nees; Jung. Bergiana L. & L.*
129β. C. fasciculatus *var* Dregeana.
129c. C. fasciculatus *var* exarita.
130. C. Lindenbergianus Nees.
131. C. lucidus Nees = *Jung. lucidus L. & L.*
132. C. oblongifolius Mitt. = *C. dubius G.*
133. C. polyanthus (Linn.) Corda; *Jung. polyanthos Linn.*

§ 2. Leaves succubous, more or less longitudinally inserted, simple, not concave, usually more or less toothed or spinose.

Genus 41. **Lophocolea.** Leaves alternate, nearly longitudinally inserted, with 2-3 large tapering teeth. Folioles bifid, with a lateral tooth on each segment. Perianth terminal on stem and main branches, 3-angled and shortly 3-lobed, the angles often winged.

134. L. aberrans L. &. G.
135. L. bidentata (Linn.) Dum. = *Jung. bidentata Linn.*
135β. L. bidentata var capensis.
136. L. coadunata Sw. & Nees. — *Jung. coadunata Sw.*
137. L. diversifolia G.
138. L. heterophylla (Schrad) Dum = *Jung. heterophylla Schr.*
139. L. heterophylloides Nees.
140. L. muricata Nees.
141. L. Rehmannii St.
142. L. semiteres (Lehm) — *Jung. semiteres Lehm; Chiloscyphus semiteres L. & L.*
143. L. setacea St.

Genus 42. **Leptoscyphus.** Leaves sub-opposite, entire or with 2-3 teeth. Foliole attached to the adjoining leaf, bifid and toothed. Perianth terminal on main stem, inflated below, laterally compressed above, 2-labiate, lips toothed. Stem procumbent, with rhizoids.

144. L. Iversoni (Pears.) — *Leioscyphus Iversoni Pears.*
145. L. sp.

Genus 43. **Tylimanthus.** Leaves with 2 or more large teeth at the apex. Folioles present, small, subulate. Stem sub-erect, with rhizoids in lower part. Marsupium solid, descending..

146. T. africanus Pears.

Genus 44. **Plagiochila.** Stems erect, without rhizoids, rising from a prostrate rhizome-like structure. Leaves decurrent; lower margin straight, apex and upper margin rounded and dentate, or with long spinous teeth. Perianth terminal, laterally compressed, the mouth dentate or ciliate. Epiphytes or sub-epiphytes.

147. P. asplenioides (Linn.) Dum. = *Jung. asplenioides Linn.*
148. P. corymbulosa Pears.
149. P. crispulo-caudata G.
150. P. heterostipa St.
151. P. Gottscheana Ldbg. = *Jung. repanda Schw (of Sprengel).*
152. P. javanica N. & M. = *Jung. javanica Swartz.*
156. P. sarmentosa Lehmn.
154. P. mascarena G.
155. P. natalensis Pears.
156. P. sarmentosa Lehm.
157. P. spinulosa (Dicks) Dum. = *Jung. spinulosa Dicks.*

§ 3. Leaves concave, 2-lobed, transversely inserted.

Genus 45. **Anastrophyllum.** Leaves ovate-pointed, shortly and unequally 2-lobed, transversely inserted, the base decurrent on the upper side of stem. Folioles usually absent. Perianth terete, plicate upward; mouth ciliate.

158. A. sp.

Genus 46. **Marsupella.** Stems sub-erect with rhizoids near the base only. Leaves equally 2-lobed, transversely inserted, complicate-concave, Folioles absent. Inflorescence terminal; involucral leaves large, connate below and also with the perianth, which is immersed below, free above, making an erect marsupium.

159. M. auritus (Nees), = *Jung. aurita Lehm.; Sarcoscyphus auritus Nees.*

Order IV. ANTHOCEROTALES.

Plants thalloid, with smooth rhizoids, and with one large chloroplast in each cell. Antheridia sunk in the upper surface of the thallus, ultimately bursting free. Sporogonium with a bulbous foot, a sheath, and a long sessile capsule, bursting from the top downward into two valves, with a central columella between. Spores maturing in succession from apex downward, and having sterile cells intermixed.

Family 16. ANTHOCEROTACEÆ. Characters of order. Always on moist soil.

Genus 47. **Anthoceros.** Thallus often flabellate, usually without distinct midrib. Capsule linear, 2-valved, the valve-surface having stomata.

160. A. crispulus (Mont) Douin = *A. punctatus var crispulus Mont.*
161. A. punctatus Linn.
162. A. minutus Mitt.
163. A. sp.

TRANSACTIONS OF SOCIETIES.

South African Institution of Engineers.—Saturday, April 8th W. Ingham, M.I.C.E., M.I.M.E., President, in the chair.—"*The Johannesburg Municipal Electric Power Station*": J. H. **Dobson.** After a few preliminary remarks on the growth of population and area of Johannesburg, which now has a quarter of a million inhabitants, the author devoted the first section of his paper to an account of the gas engine scheme, which was initiated in 1904, and, after some time of unsatisfactory operation, abandoned in 1907. The present power station steam plant was then exhaustively described, together with some account of the working results and tests on various portions of the plant. During the last six years the number of connections to the mains have increased from 5,720 to 16,091, the total units generated from 12,694,367 to 26,426,072, and the total number of street lamps from 5,340 to 7,000.

Geological Society of South Africa.—Monday, April 10th: P. A. Wagner, B.Sc., Ing.D., President, in the chair.—"*The Karroo Rocks and Later Sediments North-West of Bulawayo*": A. M. **Macgregor.** A description was given of the sedimentary rocks which lie approximately horizontally in the country within a 50-mile radius north-west of Bulawayo. These comprise: first, the Karroo beds, comprising the Forest Sandstone, overlain apparently unconformably by the Nyamandhlovu Group of Basalts and Sandstones; and secondly, sand and lateritic ironstone, correlated with the Kalahari beds of Passarge, and alluvium probably of Quaternary age, none of which had previously been systematically dealt with.—"*Diamonds from the Molteno Beds*": Prof. E. H. L. **Schwarz.** On two occasions the author had received wash from the Molteno beds, which contained brilliant specks, showing, under the microscope, all the characteristics of diamonds. These splinters were too small for commercial use, and were accompanied by red garnet, rutile, kyanite, epidote, ziron, monazite, anatase, tourmaline, and quartz, all of similar size to the diamonds.

South African Society of Civil Engineers.—Wednesday, April 12th: Prof. A. E. Snape, M.Sc., A.M.I.C.E., M.R.San.I., President, in the chair.—"*Maintenance work on the Beira and Mashonaland and Rhodesia Railways*": J. **Buchan.** The total mileage of the railways concerned is 2,471 miles. One of the chief problems in past years has been the supply of a good class of native labour. Steel sleepers were used for the track to prevent damage by white ants. Round and flat top rails of 60 lb. per yard were laid. The maximum gradient is 1 in 50, and the minimum radius of curvature is five chains. The heaviest engines in use are of 120¼ tons. The quality of water obtainable is usually good, but two borehole waters near Wankie proved unsuitable; one of these had to be abandoned and a softening process applied to the other. The maximum speed has been 35 miles per hour, and the annual costs of maintenance £75 to £80 per mile on main lines, and about £50 per mile for branches.—"*Unit Transition Curves*": F. W. **Scott.** The author described a simple method for obtaining the data for staking out the "cubic parabola" as used for transition curves, and exhibited tables compiled in a compact form for this purpose.

South African Association of Analytical Chemists.—Thursday, April 13th: J. Moir, M.A., D.Sc., President, in the chair.—"*The determination of the true reaction of waters by means of mixed indicators*": Dr. J. **Moir.** The author described the use of methyl red and α—naphtholphthalein in place of methyl orange and phenolphthalein for the determination of the true reaction of waters.—"*A simple apparatus for metallographic work*": W. O. **Andrews.**

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, April 15th: Prof J. A. Wilkinson, M.A., F.C.S., Vice-President, in the chair.—"*Concrete shaft equipment at the Bantjes Consolidated Mines*": W. W. **Lawrie** and G. **Hildick Smith** The concrete shaft equipment in the Central Shaft of the Bantjes Consolidated Mines consists of concrete shaft rail foundations as continuous stringers through the shaft. The dimensions of these concrete stringers were explained, and their materials and method of construction described, as well as the method of laying rails on the stringers.

RADIOACTIVE MINERALS IN SOUTH AFRICA.

By Prof. PAUL DANIEL HAHN, M.A., Ph.D.

(*Plates* 12-14.)

During the last eight years the author has examined a large number of South African minerals with regard to radioactivity. Up to the present six distinct minerals have been observed to be radioactitve, *viz.*, monazite, æschynite, euxenite, fergusonite, carnotite with uranium ochre, and pitch-blende. The radioactivity in these minerals is due either to the presence of uranium or thorium. The minerals which were found to be radioactitve were also analysed to determine the amounts of uranic trioxide and thoric dioxide; in none of the minerals that were analysed were uranium and thorium found together.*

MONAZITE.

The minerals containing the rare earths were considered during last century purely from a scientific point of view, principally because they had been observed only in very few localities: they were difficult to obtain, and the constituent elements did not appear to be of any practical use. The nature and composition of these minerals had been chiefly investigated by Swedish and Danish chemists. When it was found that some of the constituents of these minerals were of special value in the manufacture of incandescent lamps, search for them was made everywhere. It soon became evident that the occurrence of these minerals was by no means limited to Norway and Sweden. In the United States as well as on the coast of Brazil, near Bahia, large deposits of some of these "rare" minerals were discovered. Of these, the mineral monazite† is of special interest. It is essentially a phosphate of ceric and lanthanic sesquioxide. Its value, however, depends upon the amount of thoric dioxide, which occurs in monazite as an accessory "impurity," sometimes up to 9 per cent. Until 1895 most of the monazite was obtained from Norway, and from North and South Carolina, in the United States. Since 1895 Brazil has supplied the demand of Europe. The production of monazite in the United States was:—

In 1893—59 tons, value £1,600.
In 1894—340 tons, value £9,500.
In 1895—862 tons, value £24,000.
In 1896—8 tons, value £175.

* It is well known that some pitchblende contains as much as 6 per cent. of thoric dioxide.

† The reader will find a description of this interesting mineral in any handbook on Mineralogy.

In 1897—18 tons, value £210.
In 1898—23 tons, value £235.

During the period 1895-1898 Brazil exported 5,350 tons of monazite. At that time monazite was solely used for the preparation of thoric nitrate, required in the manufacture of the mantles of incandescent lamps. As the production of monazite rapidly increased, the price of thorium nitrate went down, the cost of one kilogram being—

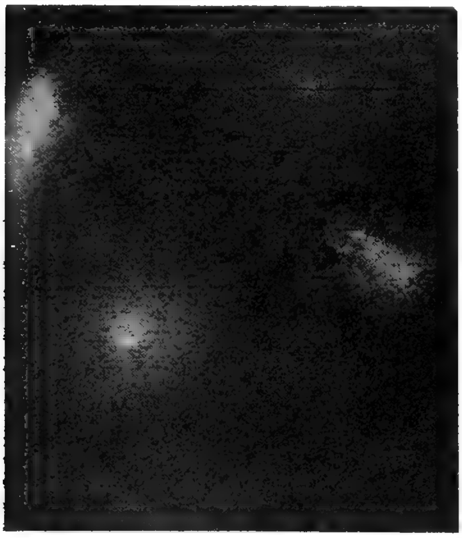
In 1894—£100.
In 1895—£22.
In 1896—£3 10s.
In 1898—£2.
In 1900—£1 8s.

Since 1900 the price of thoric nitrate has remained stationary.

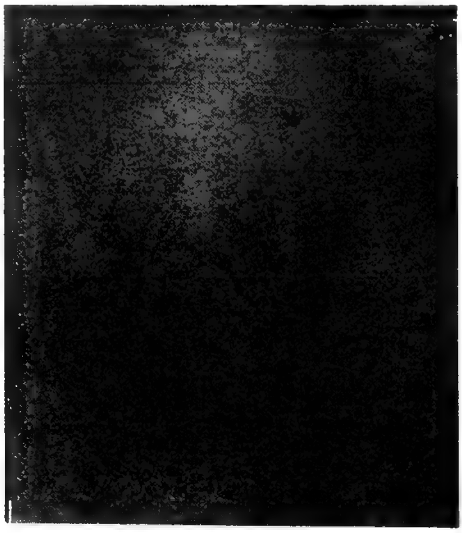
Already in 1896 small quantities of monazite were observed together with some other rare minerals like fergusonite and æschynite in the alluvial tin ore deposits near Embabaan, in Swaziland. In 1905 monazite was also discovered at Houtenbeck, in the Transvaal, together with fluorspar. The monazite of these two South African localities has been investigated, together with monazite from American localities, in the Chemical Laboratory of the South African College. The deposit at Houtenbeck was first reported upon in 1906 by Mr. Ernest Williams, of Johannesburg. A small piece of this monazite was sent to the author, who was then in Europe, and had this specimen analysed in the Fresenius Laboratory at Wiesbaden: it contained 2.3 per cent. of thoric dioxide. After his return to South Africa the author secured a large quantity of the Houtenbeck monazite, of which a number of analyses were made. The results of analyses of five different pieces of monazite from a large sample gave 1.44 per cent., 1.95 per cent., 1.99 per cent., 2.14 per cent., and 3.23 per cent. of thoric dioxide, yielding an average 2.15 per cent. The monazite of Embabaan is richer in thoric dioxide; three analyses made of three different samples yielded 6.65 per cent, 6.80 per cent., and 7.02 per cent. of thoric dioxide, or an average of 6.82 per cent.

A similar difference in the percentage of thoric dioxide is observed in the monazite sand from South Carolina, U.S.A., and from Bahia, Brazil, the latter containing between 1.5 per cent. and 3.5 per cent. of thoric dioxide, and the former on an average 7 per cent.

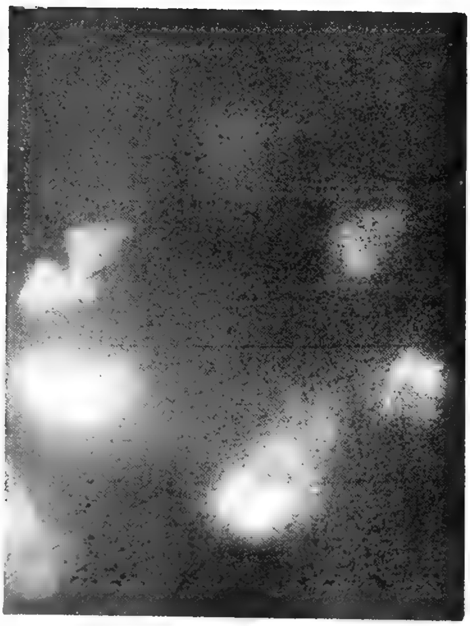
The impressions on the photographic plate produced by the radio-activity of monazite are only faint after an exposure of seven days; they are a little more distinct after an exposure of 15 days. Plate 12, *a* and *b*, show the radio-active effect on the photographic plate of monazite from Houtenbeck, and



a



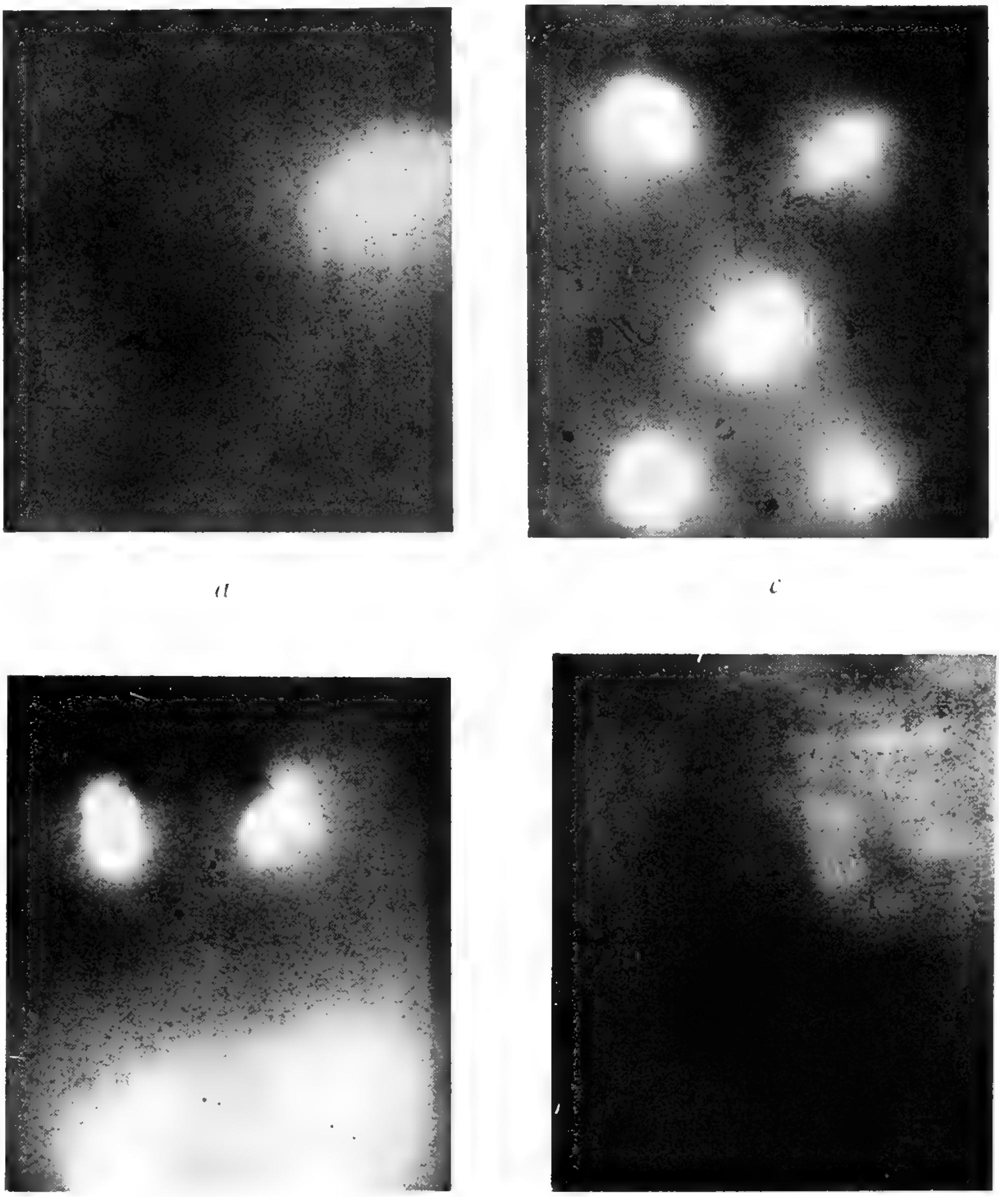
c



b

d

P. D. Hahn.—Radio-Active Minerals in South Africa.



a c b d

P. D. Hahn.—Radio-Active Minerals in South Africa.

Plate 12, *c* and *d*, from Embabaan after an exposure of seven and 15 days in each case.

As stated above, monazite has been principally used for the preparation of thoric nitrate. In the course of close investigations of the tailings of the monazite conducted during recent years, Professor Otto Hahn, of Berlin University, discovered another very powerful radio-active substance, which he called mesothorium. This substance has been found to be as effective in the treatment of cancer as radium itself. But the "life" of mesothorium is only 14 to 16 years, whereas the "life" of radium is about 2,000 years.

Æschynite.

This is a comparatively rare mineral, and has not yet been observed in large deposits or formations. At Embabaan æschynite occurs together with monazite, euxenite, fergusonite, and tin stone, as water-worn fragments up to 20 grammes in weight. It is of a somewhat complex composition, being a titano-niobate of the metals of the cerium group, containing as accessory admixture thoric dioxide, which may rise to 28 per cent. The two specimens from Embabaan analysed in the South African College Chemical Laboratory contained 16.2 per cent. and 16.7 per cent. of thoric dioxide.

The action of this æschynite on the photographic plate after exposure of seven and after 15 days respectively, is shown in Plate 13, *a* and *b*.

Euxenite.

This is one of the rare minerals found in the alluvial tin-ore deposits near Embabaan. The specimens which were analysed had been presented by Mr. R. N. Kotzé, Government Mining Engineer, Johannesburg. Euxenite has not yet been found in large deposits. It is a titano-niobate of erbium, yttrium, and cerium with an admixture of 1 per cent. to 12.12 per cent. of uranic trioxide. Three specimens of euxenite from Embabaan were analysed, and were found to contain only 1.79 per cent., 2.05 per cent., and 2.12 per cent.—on an average 1.99 per cent. uranic trixide.

The action of this euxenite on the photographic plate was very distinct. Plate 13, *c*, was obtained after an exposure of seven days.

Fergusonite.

In 1897 the presence of this rare mineral was observed in the alluvial tin ore deposits of Embabaan. It has not been observed anywhere in workable quantities. It is a tantalo-niobate of yttrium, erbium, cerium, and lanthanum, with an admixture of 1 per cent. to 6.21 per cent. of uranic trioxide. One specimen of this mineral from Embabaan contained only 1.28 per cent. of uranic trioxide.

The radio-active effect on the photographic plate was faint, even after an exposure of 10 days, as shown in Plate 13, *d*.

CARNOTITE WITH URANIUM OCHRE.

During 1913 and 1914 a very large number of specimens of tantalates and columbates from Little Namaqualand, the north-western corner of the Colony, were examined and analysed with a view to ascertaining the proportion of tantalic and niobic pentoxide in these minerals. In the course of these investigations a fine specimen of tantalite was observed to contain a yellow earthy substance embedded in a cavity, and on being exposed to the photographic plate, this substance exerted a very distinct action after seven days (see Plate 14, *a*). On analysing the yellow substance, it was found to contain 62.3 per cent. of uranic trioxide, and also a very small amount of vanadic pentoxide. The yellow earthy substance may therefore be considered a mixture of uranium ochre and carnotite, which consists principally of vanadate of uranic oxide.

PITCHBLENDE.

If we extend the boundary line of South Africa a little to the north, say to the equator, it will include German East Africa, where pitchblende has been found in considerable quantity. The author received a sample of this pitchblende in 1906 from Professor Dr. Scheibe, of the Mining Academy, Berlin. Two analyses have been made of a portion of this specimen, the results of which indicated 79.52 per cent. and 79.38 per cent. of uranic trioxide. It is very strongly radio-active; the impression on the photographic plate after an exposure of seven days is shown in Plate 14, *b*.

Up to the present I have not heard of the occurrence of pitchblende, the source of radium, in any other locality of South Africa. Considering the fact that uranium ochre and carnotite have been found in Little Namaqualand, it is not improbable that further prospecting operations will result in finding the much-sought-after pitchblende in that most desolate part of South Africa.

COMET 1916b.—In April last Prof. Wolff, of Heidelberg, announced the discovery, by means of photography, of a new minor planet. It was, however, noted that the supposed planet possessed a stellar nucleus and a nebulous envelope. This envelope subsequently developed into a small tail, and the object was discovered to be a comet. The elements of its orbit were recently computed by Berberich, and according to these it will not reach perihelion until the middle of June, 1917, fifteen months after discovery. When discovered it must have been in the vicinity of Jupiter's orbit, probably a record distance for discovery. If it should prove to be a comet of exceptional size, it may become a brilliant object towards the middle of 1917.

a

b

P. D. Hahn.—Radio-Active Minerals in South Africa.

THE MASSES OF VISUAL BINARY STARS.

By Robert Thorburn Ayton Innes, F.R.A.S., F.R.S.E.

For a general description of double stars reference may be made to any text-book on astronomy. It must suffice if we say here that some 250,000 stars have been examined, and of these 15,000 have been found to be double; but many of these double stars are not very near to each other, and it would be hopeless to expect to find any sign of gravitational motion between them. A small percentage of the total number are optical pairs, meaning that apparent proximity is only due to the point of view. When the stars of a double star revolve around each other, they form a binary system. When about half the revolution of one star around the other has been described, the actual orbit can be calculated. Although measurements of double stars have now accumulated for nearly a century—and in great number during the last half-century—very few orbits have been found, simply because in nearly every case the motion is so small. Besides this, the errors of measurement are considerable, so that until half a revolution of a pair has been accomplished it is impossible to compute a reliable orbit. Nevertheless, astronomers are certain that, with very few exceptions, all close pairs of stars are connected systems—in very many cases this is easily proved, because both stars of the pair are moving through space together, or technically, are moving with common proper motion.

In dealing with double stars, certain simple formulæ are wanted, and for purposes of easy reference these are relegated to an appendix to this paper.

Table I contains all those double stars for which fairly reliable orbits have been computed. The magnitudes and spectral classes have been taken from the Harvard Annals. Col. 8 of this table (Hypothetical Radial) gives the distance in radials (or parsecs) to which the Sun would have to be removed to shine with the same magnitude as the double star. With this hypothetical radial and P, the period, col. 9 has been computed; it gives the mass or the gravitative power—the expression "gravitative power" appears to be preferable, as mass suggests a body of matter, and it is an assumption to consider mass as equivalent to gravitative power. Col. 10 gives the measured parallax for those stars for which it is available; col. 11 is the reciprocal of this parallax or the radial. Col. 12 gives the magnitude of the Sun if removed to the distance in col. 11. Col. 13 repeats the calculation of col. 9, using, instead of the radial derived from magnitude, that derived from parallax measures. So far as this table alone goes, it is evident that many of the parallax measures are very weak, and that the distance, upon the simple assumption that all stars have the same brightness as the Sun, is about as trustworthy.

TABLE I.

Star.	1900. R.A.	1900. Dec.	Magnitude.	Spectrum.	Orbit. Period.	Orbit. Semi-axis.	Hypothetical Radial.	Measure of Gravity.	Measured Parallax.	Radial.	Sun's Mag. at distance.	Star's Gravity.	Orbit by.	Parallax by.
	h. m.	° ′			y	″			″					
δ Equuleus ..	21 9·6	+ 9 36	4·61	F5	5·70	0·27	8·36	0·36	..	..	..	..	Aitken.	..
13 Cetus	0 30·1	− 4 9	5·24	F	6·88	0·24	11·17	0·41	..	..	..	..	,,	..
κ Pegasus ..	21 40·1	+25 11	4·27	F5	11·17	0·27	7·14	0·09	..	..	..	..	Lohse.	..
Aitken 88 ..	18 33·2	− 3 17	6·47	F8	12·12	0·18	19·68	0·28	..	..	..	..	Aitken.	..
ε Hydra	8 41·5	+ 6 47	3·48	F8	15·30	0·23	4·97	0·006	..	..	..	..	,,	..
β 883	4 45·7	+10 54	6·96	F5	16·61	0·19	24·66	0·37	..	..	..	..	,,	..
ζ Sagittarius ..	18 56·2	−30 1	2·71	A2	21·17	0·56	3·48	0·018	..	..	..	..	,,	..
β 612	13 34·6	+11 15	5·54	F2	23·05	0·23	12·82	0·045	0·25	4·0:	3·0	0·001:	,,	Flint.
9 Argo	7 47·2	−13 38	5·34	Go	23·34	0·69	11·69	0·96	..	..	..	..	,,	..
β 395	0 32·2	−25 19	5·71	Ko	25·0	0·66	13·87	1·24	0·35	2·9:	2·3	0·011:	,,	Flint.
42 Coma Ber ..	13 5·1	+18 3	4·47	F5	25·3	0·67	7·83	0·23	0·06	17	6·1	2·18	Doberck.	Slocum
85 Pegasus ..	23 56·9	+26 33	5·85	G	25·4	0·81	14·79	2·61	0·09	11	5·2	1·13	Lohse.	,,
β Delphinus ..	20 32·9	+14 15	3·72	F5	26·79	0·48	5·55	0·03	..	..	..	..	Aitken.	..
β 1270	13 58·8	+ 8 58	7·5	..	32·5	0·22	31·6	0·32	..	..	..	..	,,	..
20 Perseus ..	2 47·4	+37 56	5·32	Fo	33·33	0·16	11·59	0·004	0·01	100:	10	3·70	,,	Slocum & Miller.
ζ Hercules ..	16 37·5	+31 47	3·00	Go	34·55	1·38	3·98	0·14	0·09	11	52	3·03	Doolittle.	Miller.
Σ 3121	9 12·0	+29 0	7·26	K5	35·12	0·62	28·31	4·38	0·01	100:	10	193·0	Zwiers.	Chase.
β 1266	23 25·5	+30 17	7·26	F5	36·0	0·24	28·31	0·24	..	..	..	..	Aitken.	..
Procyon	7 34·1	+ 5 29	0·48	F5	40·0	5·84	1·25	0·24	0·34	2·9	2·3	3·16	See.	Elkin.
Melb. 8 = β 416 ..	17 12·1	−34 53	5·89	K2	41·47	1·86	15·07	12·9	..	..	..	..	Voute.	..
η Corona Bor ..	15 19·1	+30 39	5·05	Go	41·56	0·89	10·23	0·44	0·08	12	5·5	0·79	Doberck & Grossmann	Slocum.
β 794	11 48·3	+74 19	6·78	..	42·0	0·34	22·70	0·27	..	..	..	..	Aitken.	..
μ Hercules BC ..	17 42·6	+27 47	9·68	..	43·23	1·30	86·3	755·3	0·04	25	7·0	18·4	,,	Russell.
μ Hercules A ..	..	..	3·48	G5	..	..	4·97	0·14	..	..	..	..	,,	..
β 1111	14 18·5	+ 8 54	6·64	Ao	44·32	0·26	21·3	0·086	..	..	..	..	,,	..
ξ Scorpio ..	15 58·9	−11 6	4·16	F8	44·70	0·72	6·79	0·06	..	..	..	..	,,	..
648	18 53·3	+32 46	5·21	G	45·85	1·04	11·02	0·70	..	..	..	..	,,	..

TABLE I.—*continued.*

Star.	1900. R.A.	1900. Dec.	Magnitude.	Spectrum.	Orbit. Period.	Orbit. Semi-axis.	Hypothetical Radial.	Measure of Gravity.	Measured Parallax.	Radial.	Sun's Mag. at distance.	Star's Gravity.	Orbit by.	Parallax by.
	h. m.	° ′			y	″			″					
Σ 2173	17 25·2	− 0 59	5·34	G5	46·0	1·06	11·69	0·90	..	..	..	..	Aitken.	..
β 581	7 58·8	+12 35	7·2	..	46·5	0·53	27·5	1·44	..	..	..	..	,,	..
ν Cygnus ..	21 10·8	+37 37	3·82	Fo	47·0	0·91	5·78	0·07	0·01	100	10	341	,,	Slocum & Miller.
Sirius	6 40·8	−16 35	−1·58	A	49·32	7·55	0·483	0·02	0·39	2·6	2·0	3·173	Lohse.	Gill and Elkin.
γ_2 Andromeda ..	1 57·8	+41 51	5·08	A	55·0	0·35	10·38	0·015	..	..	..	..	Hussey.	..
γ_1 Andromeda ..	..	..	2·28	Ko	..	..	2·86	0·0003	0·01	100	10	14·2	..	Chase.
O Σ 298	15 32·5	+40 8	6·83	G5	56·7	0·88	23·2	2·49	0·04	25	7·0	3·311	Celoria.	Russell.
Secchi 2 ..	19 7·8	+38 37	7·51	..	58·0	0·40	31·77	0·61	..	..	..	..	Aitken.	..
ξ Ursa Major ..	11 12·8	+32 6	3·86	Go	59·8	1·92	5·92	0·41	0·18	5·6	3·7	0·34	Norland.	Elkin and Chase.
ζ Cancer ..	8 6·5	+17 57	5·10	Go	60·1	0·86	10·47	0·20	..	..	..	..	Doberck.	..
99 Hercules ..	18 3·2	+30 33	5·21	F8	63·0	1·00	11·02	0·34	..	..	..	..	Aitken.	..
8 Sextans ..	9 47·5	− 7 38	5·16	A2	68·8	0·35	10·76	0·011	..	..	..	..	See.	..
O Σ 235	11 26·7	+61 38	5·47	F5	71·9	0·78	12·42	0·18	..	..	..	..	Aitken.	..
,, 400	20 6·9	+43 39	7·14	G5	74·5	0·57	26·8	0·65	..	..	..	..	Burnham & Hussey.	..
,, 234	11 25·4	+41 50	6·99	F5	77·0	0·35	25·0	0·11	..	..	..	..	See.	..
α Centaurus ..	14 32·8	−60 25	0·01	G & K5	79·3	17·7	1·005	0·90	0·76	1·3	0·6	2·00	Lohse.	Gill.
70 Ophiuchus ..	18 0·4	+ 2 31	4·07	Ko	87·9	4·56	6·52	3·40	0·22	4·5	3·3	1·16	Lohse.	Slocum.
γ Centaurus ..	12 36·0	−48 25	2·38	Ao	88·0	1·02	2·99	0·004	..	..	..	..	See.	..
O Σ 79	4 14·2	+10 17	6·86	..	88·9	0·62	23·6	0·40	..	..	..	..	Aitken.	..
,, 4	0 11·5	+35 56	7·70	..	90:	0·4:	34·7	0·3:	0·12	8·3	4·6	0·005	,,	Cederstrand.
Dembowski ..	16 40·8	+43 40	7·3	..	96·0	0·84	28·8	1·54	..	..	..	..	See.	..
O Σ 387	19 45·0	+35 3	6·52	F2	96:	0·54	20·1	0·14	..	..	..	..	Lohse.	..
,, 285	14 41·7	+42 48	7·24	F5	97·9	0·34	28·0	0·09	..	..	..	..	V. Biesbroeck.	..

TABLE I.—*continued.*

Star.	1900. R.A.	1900. Dec.	Magnitude.	Spectrum.	Orbit. Period.	Orbit. Semi-axis.	Hypothetical Radial.	Measure of Gravity.	Measured Parallax.	Radial.	Sun's Mag. at distance.	Star's Gravity.	Orbit by.	Parallax by.
	h. m.	° ′			y	″			″					
ϕ Ursa Major	9 45·3	+54 32	4·54	A2	99·7	0·32	8·09	0·002	..	..	..	..	Doberck.	..
Σ 3123	12 1·1	+69 15	7·14	F5	103·3	0·32	26·8	0·06	..	..	..	..	See.	..
H. I. 39	0 1·0	+57 53	6·10	F	105·7	1·49	16·6	1·36	..	..	..	..	Lohse.	..
36 Andromeda ..	0 49·6	+23 5	5·60	Ko	114·8	1·01	13·2	0·18	..	..	..	..	Bowyer.	..
π Ursa Minor ..	15 45·1	+80 17	6·93	..	115·0	0·42	24·3	0·08	..	..	..	..	Aitken.	..
ν Leo	9 23·1	+ 9 30	5·52	G	116·7	0·84	12·7	0·09	..	..	..	..	Doberck.	..
λ Ophiuchus ..	16 25·9	+ 2 12	3·85	Ao	123·2	0·98	5·89	0·013	..	..	..	..	Lohse.	..
γ Corona Aust. ..	18 59·7	−37 12	4·20	F8	124·6	2·14	7·11	0·23	..	..	..	..	Doberck.	..
Σ 2	0 3·8	+79 10	6·22	A2	128·6	0·61	17·5	0·074	..	..	..	..	Dale.	..
Σ 2107	16 47·9	+28 50	6·52	..	134·6	0·68	20·1	0·15	..	..	..	..	Lohse	..
Σ 483	3 57·4	+39 14	7·18	..	135·5	1·77	27·3	6·14	..	..	..	..	See.	..
4 Aquarius ..	20 46·1	− 6 0	5·99	Fo	135·6	0·64	15·8	0·06	..	..	..	..	Aitken.	..
ξ Bootes ..	14 46·8	+19 31	4·64	G5	159·5	4·97	8·47	2·93	..	..	..	..	Lohse.	..
Σ 2026	16 11·1	+ 7 37	8·1	..	163·3	1·56	41·7	10·34	..	..	..	..	Aitken.	..
ζ Bootes	14 36·4	+14 9	3·86	A2	170·6	1·11	5·92	0·01	..	..	..	..	Lohse.	..
γ Virgo	12 36·6	− 0 54	2·90	F	177·8	3·62	3·80	0·08	0·07	14	5·8	4·43	,,	Russell.
o_2 Eridanus BC ..	4 10·8	− 7 49	8·9	..	180·0	6·25	60·3	1650·	..	..	..	..	Burnham & Doolittle.	..
o_2 Eridanus A ..	..	..	4·48	G5	..	..	7·78	3·67	0·18	5·6	3·7	1·29	..	Gill.
Σ 2438	18 55·8	+58 5	6·31	A	233·0	0·53	18·3	0·015	..	..	..	..	See.	..
μ_2 Bootes ..	15 20·7	+37 42	6·66	Ko	244·4	1·44	21·5	0·49	..	..	..	..	Doberck & Grossmann	..
μ_1 Bootes ..	..	..	4·47	Fo	..	..	7·83	0·024	..	..	..	..	..	..
Castor	7 28·2	+32 6	1·58	A	249·3	7·58	2·07	0·062	0·11	9	4·8	5·26	Lohse.	Russell.
p Eridanus ..	1 36·0	−56 42	5·26	G5	302·4	6·96	11·3	5·29	..	..	..	..	Gore.	..
η Cassiopeia ..	0 43·0	+57 17	3·64	F8	345·6	10·10	5·35	1·33	0·19	5·3	3·6	1·00	Lohse.	Russell.

Table II is a list complete for the first two hours of R.A., and complete to magnitude 5.3 for the remainder, of all stars given in Burnham's General Catalogue for which the type of spectrum is given in Harvard Annals, Vol. LVI, No. 7 (Spectra of 745 Doubles by Annie J. Cannon), for which the apparent distance is under 1″.2. Stars appearing in Table I are excluded.

TABLE II.

Star.	1900. R.A.			1900. Dec.		Magnitude.	Spectrum.	Distance.	Annual Motion in Angle.	Annual Motion for Sun Type.
	h.	m.	s.	°	′			″	°	°
κ Sculptor	0	4	3	−28	33	5·46	F2	0·95	0·0	9 ±
Σ 13 ..	0	10	6	+76	24	6·23	A	0·78	0·7	7
λ Cassiopeia	0	26	2	+53	59	4·88	B5	0·50	0·5	40
β 395 ..	0	32	2	−25	19	5·7	Ko	0·5	:	20
β 495 ..	0	43	5	+18	8	7·6	F5	0·60	0·0	4
66 Pisces ..	0	49	3	+18	38	5·8	Ao	0·5	2·0	20
β 1099 ..	0	50	8	+59	50	5·5	B8	0·20	3·6	95
Ho. 213 ..	0	58	5	+34	55	7·2	Ao	0·3	2·4	15
φ Andromeda	1	3	7	+46	42	4·28	B8	0·33	1·7	100
β 303 ..	1	4	3	+23	16	6·6	Fo	0·6	0·0	8
β 235 ..	1	4	6	+50	28	6·9	F2	0·8	0·6	4
β 1100 ..	1	7	7	+60	21	7·3	A	0·7	0:	2
β 4	1	16	1	+11·1		6·9	Fo	0·4	0·4	12
Hu 6 ..	1	17	0	+57	37	6·4	F5	0·6	..	..
β 1163 ..	1	19	4	−7	6	6·0	F2	0·4	0:	22
95 Pisces ..	1	22	4	+4	51	7·3	K	0·4	0:	9
O Σ 34 ..	1	38	8	+80	23	7·2	A	0·5	0·5	7
Ho 311 ..	1	45	7	+24	10	6·9	A5	0·4	0·3	10
Σ 186 ..	1	50	7	+1	21	6·2	F5	0·7	4	9
48 Cassiopeia	1	53	8	+70	25	4·61	A3	0·8	8·0	20
ε Aries ..	2	53	5	+20	56	4·64	A2	1·2	0·2	15
η Orion ..	5	19	4	−2	29	3·44	B1	1·10	0·0	25
32 " ..	5	25	4	+5	52	4·32	B3	0·6	0·9	40
σ " ..	5	33	7	−2	39	3·94	Bo	0·25	1·9	200
126 Taurus ..	5	35	5	+16	29	4·87	B3	0·2	(12·±)	130
15 Lynx ..	6	48	6	+58	33	4·54	Ko	0·55	0·9	45
β 208 ..	8	34	8	−22	19	5·13	G5	1·0	3±	10
υ Serpens ..	15	37	1	+20	0	4·49	A2	0·2	4±	200
ν Scorpio ..	16	6	2	−19	12	4·16	B3	0·8	0·2	30
η Ophiuchus	17	4	6	−15	36	2·63	Ao	0·4	1·9	270
φ Draco ..	18	22	2	+71	17	4·24	Aop	0·4	0·0	80
χ Aquila ..	19	37	9	+11	35	5·32	F5 & A	0·5	0·0	28
ζ Sagittarius	19	44	5	+18	53	4·95	Ao	0·25	0·0	100
ν Capricornus	20	33	7	−15	18	5·30	B5	0·16	2·5	160
λ Cygnus ..	20	43	5	+36	7	4·47	B5	0·65	1·0	30
1 Equuleus ..	20	54	1	+3	55	5·29	F5	1·0	0·2	10
π Cepheus ..	23	4	7	+74	51	4·56	G5	1·2	1·8	14
72 Pegasus ..	23	29	0	+30	46	5·21	K2	0·4	1·5	40

: Signifies angular motion doubtful but very small.

It is to be expected that the knowledge of double stars will aid in solving the problems of the stellar system. If we could look at the Sun from a distance represented by a parallax of 1″, we should see the Earth revolving around it at a mean distance

of 1″ in one year. Actually we would not be able to see the Earth because it would be too faint. But there are other systems; let us take *α* Centaurus, for example; it is a double star with a parallax of 0″.76 (radial or distance = 1.32) with a mass equal to 1.9 times the Sun's mass. The chief star of *α* Centaurus appears to be an exact duplicate of the Sun. We can therefore ask if replicas of this system are to be found elsewhere in the heavens. Thus, if there is a similar system ten times as far away, it would appear to us as a 5th magnitude pair with a period of 80 years and a mean distance or semiaxis major of 1″.8. Table I will enable us to answer this question by inspection, and it shows us that in the quarter of a million stars examined by double-star investigators there are but two or three stars which appear to be of the *α* Centaurus or Sun type; of the remainining millions of fainter stars (10th to 13th magnitude) it can be safely inferred there is amongst them no double star of this type.

Table I may be considered complete for all stars brighter than the 8th magnitude, and whose periods are less than 90 years, and which are not closer than 0″.4. This being so, we remark first that, excepting the double companion of *μ* Hercules, there is no star so faint as 8th magnitude in the list. Let us consider what this means. If the Sun was removed to such a distance that it was of the 8th magnitude, it would then be 40 radials away (π = 0″.025), and a companion at an angular distance of 0″.50 would revolve around it in 90 years.

We can safely say that there is no such double star in the heavens. There are very many pairs of stars about 0″.5 apart, and with a combined magniture of 8.0, but their motion is so slow that their periods must be not only greater, but very much greater than 90 years.

Hence the evidence of the known double stars is that stars of the 8th magnitude have less gravitative power than the Sun, probably without any exception. This line of argument applies to all magnitudes. Thus, if the Sun was removed to such a distance that its magnitude was 5.0, its radial would be 10 (corresponding to π = 0″.10), and companions to it would have semi-axes and periods as follows:—

Distance or Semiaxis. ″	Period. Year.
0.10	1.0
0.30	5.2
0.40	8.0
0.50	11.2
0.60	14.7
0.80	22.6
1.00	31.6

A comparison of this table with Tables I and II at once shows that few of the double stars therein have gravitative power equal

to that of the Sun; but we can go much further, and show that most of the double stars fall far short indeed. For this purpose the data can be arranged differently.

In comparing the gravitative power of the Sun with that of a double star, we may consider the two extreme cases. In the two-body motion, the total mass is M_1+M_2, M_1 being the mass of the primary, M_2 of the secondary. In the solar system M_1 would be the Sun, M_2 the Earth; in this case M_2 is so small, compared to M_1 (1/330,000), that it becomes negligible. At the other extreme M_2 may be equal to M_1, as is the case with many double stars. It is highly improbable that we could see the companion in any double star system where the ratio of M_2 to M_1 is only 1 to 330,000. Sirius and Procyon have very faint companions, but their gravitative powers are not widely out of proportion to those of their primaries; thus, in the case of Sirius we have $M_1 = 2.4$ and M_2 1.1, the unit of gravitative power being that of our Sun.

TABLE III.

Magnitudes of Solar-Type Pairs for Different Masses.

m, Combined magnitude; m_1, magnitude of chief star; m_2, magnitude of companion star; M, mass or gravitative power of system; M_1, mass of chief star; M_2, mass of companion star.

m	m_1	m_2	M	M_1	M_2
0.00	0.00	6.00	1.0	1.00	0.000
−0.01	0.00	5.00	1.0	0.999	0.001
−0.04	0.01	3.33	1.0	0.99	0.01
−0.06	0.02	2.83	1.0	0.98	0.02
−0.10	0.04	2.17	1.0	0.95	0.05
−0.15	0.08	1.67	1.0	0.9	0.1
−0.20	0.16	1.16	1.0	0.8	0.2
−0.24	0.26	0.85	1.0	0.7	0.3
−0.25	0.37	0.66	1.0	0.6	0.4
−0.25	0.50	0.50	1.0	0.5	0.5

$m_2 - m_1$		M_1/M_2
0.0	....	1.0
1.0	....	4.0
2.0	....	15.8
3.0	....	63.1
4.0	....	251.2
5.0	....	1000.0

If, as stated earlier, the Sun was removed to a distance of 1 radial (parallax 1″), it would shine as a star of the 0.0 magnitude, and the Earth would revolve around it under a semiaxis of 1″ in one year's time. If, however, the two bodies were equal in size—which we may imagine would be got by creating two

globes out of the solar orb—the magnitude would no longer be 0.0, because the light emitting surface has now been increased. The increase in magnitude is $= -5/6 \log. 2 = -0.25$, or each star would have the magnitude of 0.50, whilst, as before, the semiaxis would be 1″ and the period one year.

This would be a model system resembling our Sun in surface brilliancy and gravitative power.

The magnitude, period, and semiaxis of any double star in themselves tell us nothing about its distance because of spatial relations. Let us consider two systems of equal emissive brilliancy per unit area, but one twice as far from us as the other. If the further one has eight times the mass (or gravitative power), it will have four times the area, and therefore the same apparent brightness. Hence, as seen in the sky, these two systems would appear to be identical in every respect. Because we know the parallax of *a* Centaurus, we have learnt that its mass is 1.9 ☉ (nearly twice the gravitative power of the Sun). If its parallax had been half what it is, then its visual appearance would have been the same if its mass had been 15.2 ☉. And generally, as the distance increases p times, the mass increases p^3 times, if the visual appearance remains unchanged.

In this argument an assumption has crept in, namely, that the spectral type is independent of the mass. We have no proof that stars eight times the mass of *a* Centaurus could exhibit its spectrum. At the same time we cannot assert that a star's spectrum alters with its mass. It has also been assumed, and will be maintained, that that stars of similar spectra have equal emissive power or brilliancy per unit area.

In all the cases where we have both good determinations of the orbits and parallaxes of double stars we find that their gravitative power does not differ greatly from that of the Sun; let us take the most reliable results from Table I.

Star.	Spectrum	Gravitative Power.
85 Pegasus	G	1.13
ζ Hercules	G	3.03
Procyon	F_5	3.16
η Corona Borealis	G	0.79
Sirius	A	3.17
a Centaurus	G-K	1.95
70 Ophiuchus	K_0	1.16
η Cassiopeia	F_8	1.00

To find out by a simple and rapid inspection the relations between mass, magnitude and distance, Table IV has been prepared. The right-hand portion of Table IV within leaded lines may be omitted, as no known double stars fall within it.

Excepting the columns "Radial for Given Masses," the table is to be interpreted as actual experience. Thus, if there was in the heavens a double star with equal-sized components, whose magnitude is 3.75, and whose angular separation is 9″, if it is

TABLE IV.

Average Angular Motion of Solar Type Double Stars.

Radials for given Masses.								Magnitude.		Annual Angular Motion at given Distances.					
$1000 \times \odot$	$512 \times \odot$	$216 \times \odot$	$64 \times \odot$	$8 \times \odot$	$1 \times \odot$	$\frac{1}{8} \times \odot$	$1/64 \times \odot$	Size equal.	Size very unequal.	16″	9″	4″	1″	0″.25	0″.11
10	8.0	6.0	4.0	2.0	1.0	0.5	0.25	0.25	0.0	5°.6	13°	45°	360°	2880	9720
16	13	9.5	6.3	3.2	1.6	0.8	0.40	0.75	1.0	2.8	6.7	23	180	1443	4872
25	20	15	10	5.0	2.5	1.3	0.63	1.75	2.0	1.4	3.3	11	90	723	2442
40	32	24	16	8.0	4.0	2.0	1.0	2.75	3.0	0.71	1.7	5.7	45	363	1224
63	50	38	25	13	6.3	3.2	1.6	3.75	4.0	0.36	0.84	2.9	23	182	613
100	80	60	40	20	10	5.0	2.5	4.75	5.0	0.18	0.42	1.4	11	91	307
158	126	95	63	32	16	8.0	4.0	5.75	6.0	0.089	0.21	0.72	5.7	46	154
251	201	151	100	50	25	13	6.3	6.75	7.0	0.045	0.11	0.36	2.9	23	77
398	318	239	159	80	40	20	10	7.75	8.0	0.022	0.053	0.18	1.4	11	39
631	505	379	252	126	63	32	16	8.75	9.0	0.011	0.027	0.09	0.72	5.7	19
1000	800	600	400	200	100	50	25	9.75	10.0	0.006	0.013	0.045	0.36	2.8	9.7
1/100	1/64	1/36	1/16	1/4	1	4	16								

a solar type star, the annual change of position angle would be about 0°.84, but its distance and mass are indeterminate. It might be any of the following:—

Mass (Sun Unity).	Distance (in Radials).
1,000	63
512	50
216	38
64	25
8	13
1	6.3
⅛	3.2
1/64	1.6

so far as the table goes. It can be continued further by the factors at the foot of the first eight columns, which will furnish the inverse or reciprocal masses; thus, if we read the first column, not as 1,000 times the Sun's mass, but as 1/1000th of it, we must multiply the radial distance by 1/100th, and so on, yielding the example—

Mass (Sun Unity).	Distance (in Radials).
1/1000	0.63
1/512	0.78
1/216	1.1
1/64	1.6
1/8	3.2

coming again in the last two cases to figures already tabulated. Intermediate numbers can be found from the relation—

$$\text{Mass}/(\text{Radial})^3 = \text{Constant},$$

but the table need only be used for qualitative inspection. As already stated, Table IV, in the columns headed Magnitudes and Distances, covers all our observational experience; that is, we know nothing of double stars fainter than 10th magnitude (corresponding to about 9.3 in the B.D. scale of magnitudes), the case of unequal pairs such as, say, 10.1 and 12.1, or of 9.75 in the case of equal pairs, and as regards distances, we know little or nothing of pairs under 0″.25 apart.

The table can perhaps best be interpreted negatively. We know that *a* Centaurus at 17″.7 moves over 4°.35 a year. Is there any similar pair, nearer or further away? It is unlikely that any are nearer, but within a space covered by 100 radials we might expect to find 1,000,000 such pairs, ranging to the 9.75 magnitude if of the mass of the Sun or of ($1{,}000^3$) if of 1,000 times the mass of the sun, because for such stars the limiting radial is 1,000. There are about six such pairs. Hence stars of the size of *a* Centaurus are very few indeed—they are exceptional stars.

Then, we know of several pairs of stars revolving in about

40 years at a distance of about 1″ with measured parallaxes of about 0″.1, or at a radial distance of 10. These stars, it is at once apparent, are of about the Sun's mass. Are there any of these stars nearer than 10 radials? The table says, No! Are there any of these 40-year stars (9° per annum) of enormous mass and at great distance but about 5th magnitude? Again the table replies, No! Do we know of any very close pair 0″.25 or so, and faint, say 9th magnitude, moving over 9° a year? If so, it might be a very massive star at a great distance. Thus a double star 1,000 times the Sun's mass, at a radial of 1,000, and at a distance of 0″.25, would move over 2°.8 a year. There is no such pair.

When every allowance is made for the weakness of some of the assumptions, it is still impossible to resist the main conclusion to be drawn from the tables, namely, that the stars are not models of the Sun—that in general their gravitative power is very much smaller indeed, and in some cases, as is shown in Table II, seems to be quite insignificant. This especially applies to the spectral classes B, A, and F. Classes O and M are not represented in either table, indicating, again, very small gravitative power, whilst classes G (solar type) and K have in a few cases gravitative power of the same order as the Sun.

If we take the simple means of Col. 9 in Table 1 by the classes A, F, G, and K, we find the gravitative power is as follows:—

A	0.02
F	0.27
G	1.23
K	3.30

And this table contains all the best-known and nearest stars. The enormous disproportion thus revealed between luminosity and energy should not be surprising—a rude analogy is furnished by considering a locomotive and its electric headlight, in which practically all the energy is in the nearly black body of the locomotive, and all the luminosity in the small lamp-filament. The cases of a few typical pairs will be specifically dealt with.

λ ORION.—*Magnitude* 3.49 (*components* 3.66 *and* 5.56). *Spectrum* *Oe*5.

This is one of the few double stars of the Oe class, and like them all, shows no change whatever. That this is a real and not optical pair is proved by their common proper motion 0″.028, which in the century this pair has been under observation, would have increased the distance by 2″.8, or from about 4″.4 to 7″.2; there has been no change. The effective gravitative power of this pair and of all other Oe stars must be quite trifling.

There are no double stars of spectral type Oa to Od. The spectrum Oe has helium and hydrogen lines and two bright bands at 4633 and 4688. metallic lines are absent.

a CRUX.—*Magnitude* 1.05 (*components* 1.58 *and* 2.09). *Spectrum B*1.

These two bright stars form one of the most beautiful double stars in the whole sky. Their distance apart is 5″. Although they have been measured frequently since 1826, it is still quite uncertain if there is any change. Certainly the angle is unchanged, but the distance may have decreased slightly. If we assume that a solar-type double star of equal size would shine as a star of the 4th magnitude at the distance of *a* Crux, then it would revolve at the rate of from 1 to 2 degrees a year. There is no such change in this pair. Let us hear what Newcomb says concerning the somewhat similar pair ζ Orion, Magnitude 1.91 (components 2.05 and 4.21.) Spectrum B0:—

This star, in the belt of Orion, is of the 2nd magnitude. It has a minute companion at a distance of 2″.5. Were it a model of the Sun, a companion at this apparent distance should perform its revolutions in 14 years. But, as a matter of fact, the motion is so slow, that even now, after 50 years of observation, it cannot be determined with any precision. It is probably less than 0°.1 in a year. The number expressing the comparison of the density and surface brilliancy of this star with those of the Sun is probably less than 0.0001. The general conclusion to be drawn is obvious. The stars in general are not models of our Sun, but have a much smaller mass in proportion to the light they give than has our Sun ("The Stars: A Study of the Universe," p. 200).

Gravitational motion is, however, exhibited in some of the earlier B type stars. Thus with σ Orion, magnitude 3.94, Spectrum B0, the angle has changed 28° in 13 years, the distance remaining constant at 0″.25. If this star had been a model of the Sun, the change would have been about 180° a year, or 2,300° instead of 28°.

The spectra B0 and B1 have intense helium lines; there are no metallic lines.

SIRIUS.—*Magnitude* −1.58 (*components* −1.58 *and* 9.0). *Spectrum A.*

Auwers found 2.125 for the ratio of the mass* of the larger and brighter component to that of the smaller.† Hence we have for Sirius 2.16 ☉, and for the companion 1.01 ☉.

At the distance represented by the parallax 0″.39, the Sun would shine as a star of the 2.04 magnitude. Solar-type stars of the masses 2.16 and 1.01 would shine as stars of the 1.48 and 2.03 magnitudes. Thus, so far as concerns Sirius, we can say that, mass for mass, it emits so much more light that it gains 3.06 magnitudes—that is, an A type star, mass for mass, is three magnitudes brighter than a G type star.

The spectrum of the companion has not been determined.‡

* Using "mass" as the equivalent of gravitative power.

† *Ast. Nach.*, 3085.

‡ Since the above was written, a note dealing with the spectrum of the companion of Sirius has been published by Dr. W. S. Adams, in the December, 1915, issue of the *Publications of the Astron. Soc. of the Pacific*, pp. 236-7. He finds that the spectrum of the companion is identical with that of Sirius, but that there appears to be a slight tendency for the continuous spectrum to fade off more rapidly in the violet region.

There is no contrast of colour as seen in the telescope; indeed, the hue is so similar that it is often difficult to distinguish the companion from pieces of the diffraction rings which surround Sirius or from ghost images of Sirius formed by reflexions within the eyepiece. It may therefore fairly be assumed that the companion has a similar type of spectrum. But, mass for mass, it only shines as a star of the 9th magnitude against the Sun's 2.03 magnitude at equal distance—a loss of no less than seven magnitudes, or, in other words, its light emission is only 1/631 that of the Sun. One is forced to accept the difficult conclusion that the light of the companion of Sirius is in some way affected by Sirius itself. Otherwise we should expect to find some other stars of about the 9th magnitude with similar gravitative power, but there are certainly none whatever known.

Spectral class A0, of which Sirius is the typical member, has the hydrogen lines at their maximum intensity. Metallic or solar lines are present, but are very faint.

μ HERCULES.—*Triple System. Chief component, magnitude* 3.48. Spectrum G5.

Binary companion, magnitude 9.68 (10 and 11).

The parallax of μ Hercules has been determined twice:—

Russell (photographs) ...	$0''.038 \pm 0''.036$
Chase (heliometer)	$0''.122 \pm 0''.028$

To shine as a 3.48 magnitude star the Sun must be removed to 4.97 radials (parallax $= 0''.20$).

The spectral class G5 has weak hydrogen and very strong metallic lines.

Struve noted the colours as yellow and blue. Yet the binary companion is 6.2 magnitudes fainted than its primary.

GRAVITATIVE POWER OF THE BINARY COMPANION OF μ HERCULES AT VARIOUS DISTANCES.

Radial.	Parallax. ″	Gravitative Power.
5.0	0.20	0.15
6.0	0.17	0.25
7.0	0.14	0.40
8.0	0.12	0.60
10.0	0.10	1.18
12.5	0.08	2.30
20.0	0.05	9.40
25.0	0.04	18.35

The magnitude of a solar type star at these distances and powers would remain constant at 6.55. Thus, the companion, in spite of its bluish tint, is three magnitudes fainter than a solar type star of similar gravitative power would be.

We may ask the question: Are there similar pairs to this binary companion of the 9.68 magnitude with a semiaxis of $1''.30$ and a period of 43.2 years? None are known, but few

stars so faint as 9.68 magnitude have been followed up as double stars. But if this binary was only one of many to be found at varying distances then it has no representatives amongst stars brighter than itself. We may therefore conclude that it is an exceptional pair, like other pairs found in proximity to a bright star. (See, for examples, o_2 Eridanus and μ Bootes in Table 1.) It would seem from from these cases, and the faint companions to Sirius and Procyon, that the proximity of a bright star in a binary or ternary system has some power of inhibiting the emission of light in its attendants.

ALDERARAN.—*Magnitude* 1.06. *Spectrum K2.*

This bright star has a 13.5 magnitude companion at a distance of 31″.2, which is travelling with it through space with an annual velocity of 0″.188 (Auwers), but since 1877, the year of its discovery by Burnham, up to the last measures made there has been no relative change of measurable amount.

According to Elkin, the parallax of Aldebaran is 0″.11, giving as its radial 9. If we can assume that the companion is at its mean distance, and assume its radius vector is inclined 60° to the tangent plane, its semiaxis major is of the order of 327 units. The Sun would compel a body at this distance to revolve around it in about 6,000 years, making an angular change of about 1½° in 28 years. It is certain that the companion of Aldebaran has not changed by that amount, and therefore the period of revolution is longer, and consequently the mass of Aldebaran smaller, than that of the Sun. A star with so strong an absorbing atmosphere as is indicated by the spectrum K2, loses probably 1.06 magnitudes at least as compared with a solar type star. Let us consider this assumption for a moment. It would mean that the distance of Aldebaran is only one radial. At such a distance the gravitative power of the Sun would force a planet at the distance of Aldebaran's companion to move over 2° a year, or about 50 degrees in 28 years. As no such change occurs, it is evident that Aldebaran is not similar to the Sun in gravitative power. Besides this, the Sun at 9 radials distance would only shine as a star of the 1.56 magnitude, or ½ a magnitude fainter than Aldebaran, in spite of the latter having a strongly absorbent atmosphere.

Again, let us assume that Aldebaran is more distant than its measured parallax indicate. Let us suppose it is 100 radials away. The Sun at such a distance would shine like a 10th magnitude star. At this distance its gravitative power upon a companion so distance as 31″.2 would be insignificant, and therefore comparable with Aldebaran's. But allowing for absorption, this would mean that Aldebaran has 25,000 times the Sun's mass, and that the companion moves through about 10° in 28 years—so that this assumption must also be dismissed.

Thus we are involved in contradictions every way, and we can only escape from them by acknowledging that Aldebaran

as it is could not have evolved from a solar type star by a process of cooling.

The spectral class K2 shows a general faintness towards the violet end; bands K and H are very strong.

ANTARES.—*Magnitude 1.22. Spectrum, Ma, peculiar.*

This bright star has a 7.0 magnitude companion of a bluish tint at 3″.1 distance. Neither angle nor distance are changing, or if the angle is changing, the change is under 0°.05 a year. It is remarkable that when the colours of a double star are contrasted there is seldom any motion, and no orbit has yet been found for such a pair. On the contrary, in the cases of well-known binary pairs, the hue or colours of the stars is almost identical. In *a* Centaurus both stars are yellow, but the fainter star is decidedly yellower, the respective spectra being Go and K5, or in contiguous classes, and even this slight difference is unusual, the fainter component of a double star being usually bluer than the brighter. Antares and its companion have a small common proper motion which is more than large enough to make it certain that they form a system, but the bond of union is not that of gravitation. The spectrum is peculiar in showing indications of an A type spectrum, in addition to an ordinary Ma spectrum, but this is probably due to the companion, which is perhaps not so faint as 7.0 magnitude. It is probable that the strongly absorbing atmosphere of Antares, as indicated by its spectrum, reduces its magnitude by three steps at least, so that, were it not for its absorbing atmosphere, it would shine as a star of the –1.8 magnitude. A solar-type star of that magnitude would cause a companion at 3″ to move over from 30 to 90 degrees a year. There is no such motion; the inference cannot be avoided, namely, that Antares and its companion have exceedingly small gravitative power, of if they have it, that it is in some way neutralised by some other force.

Dr. Coblenz, of Washington, has recently put a new instrument at the disposal of astronomers which measures the total intensity of radiation. With this instrument it is found that if our eyes had the same sensitivity curve as the radiometer, Antares and Betelgeux would be the two brightest stars in the sky. Hence we must conclude that stellar radiant energy is not related in any simple way to gravitative power. For a description of the new "stellar radiometry" reference may be made to Dr. Kevin Burns's paper in the June number of the *Publications of the Astronomical Society of the Pacific*.

The spectrum Ma is banded; the two bands faintly seen in K5 are now well marked.

a HERCULES.—*Magnitude 3.31 (components 3.46 and 5.54). Spectrum Mb and (A).*

The principle star is variable (3.1 to 3.9), and the companion is 4″.6 distant. They form a system because they have common proper motion. The position is slowly changing, but,

according to Lewis, the relative motion is convex, so that the gravitative force is more than negatived by some other force.

The spectral class Mb has numerous bands.

* * * * * *

Let us arrange the stars of Table I in their spectral classes A, F, G, and B, and compare the number of each class with expectancy. According to Prof. E. C. Pickering (Harvard Annals, Vol. 56, p. 19, Table VI), the proportionate number of stars all over the sky are:

B	A	F	G	K	M
2	81	25	11	34	2

As Table I just contains 25 stars of class F, we should expect to find the other types in the same proportion; actually we have:

0	12	25	14	6	0

or, in percentages of expectancy,

...	14	100	128	16	... per cent.

There are too few B and M type stars to afford us any information, but the low percentage of A and K type stars is remarkable, and it appears that G type stars are somewhat over-represented amongst the rapid binaries. The argument used in the previous pages renders it now very certain that, in spite of their great number, the A type is poorly represented amongst binaries, because stars of that class have but little gravitative power, for all their brilliancy. In the case of the K type, the scarcity would appear to be solely due to the long periods of such pairs—but long periods can only be due to absolutely large mean distances. Classification by spectrum strengthens this suggestion.

Table V is arranged accordingly, and in order of period.

The stars in this table below the broken lines have periods of over a century.

The third column in each class gives the mean distance in terms of the Earth's mean distance from the Sun, found by multiplying the mean distance in seconds of arc by the number whose logarithm is the star's magnitude divided by 5.

When these columns of the four classes are considered, it will be at once remarked that no binary stars with distances under 0″.57 appear in classes G and K—nearly all the very close pairs are found in classes A and F, but nearly all in F. Thus, of systems under 0″.70 in any given class,

Class A has 60 per cent.
Class F has 64 per cent.
Classes G and K have 20 per cent.

There is no self-evident reason why there should not be close and rapid binary pairs in the two last classes. The smallest semi-axis major is that of **OΣ** 400 = 0″.57, and why should there not be many pairs at half that distance and of about one-third of the

TABLE V.

A.

Star.	Angular distance.	Hyp. distance.	Spectrum.
	″		
ζ Sagittarius	0·56	1·9	A2
β 1111 ..	0·26	5·5	A0
Sirius ..	7·55	3·6	A
γ_2 Andromeda	0·35	3·6	A
8 Sextans ..	0·35	3·8	A2
γ Centaurus	1·02	3·0	A0
φ Ursa Maj.	0·32	2·6	A2
λ Ophiuchus	0·98	5·8	A0
Σ 2	0·61	10·7	A2
ζ Bootes ..	1·11	6·6	A2
Σ 2438 ..	0·53	9·7	A
Castor ..	7·58	15·7	A

F.

Star.	Angular distance.	Hyp. distance.	Spectrum.
	″		
δ Equuleus	0·27	2·3	F5
13 Cetus ..	0·24	2·7	F
κ Pegasus ..	0·27	1·9	F5
Aitken 88 ..	0·18	3·5	F8
ε Hydra ..	0·23	1·1	F8
β 883 ..	0·19	4·7	F5
β 612 ..	0·23	2·9	F2
42 Coma Ber.	0·67	5·2	F5
β Delphinus	0·48	2·7	F5
20 Perseus	0·16	1·9	F0
β 1266 ..	0·24	6·8	F5
Procyon ..	5·84	7·3	F5
ξ Scorpio ..	0·72	4·9	F8
τ Cygnus ..	0·91	5·3	F0
99 Hercules	1·00	11·0	F8
O Σ 235 ..	0·78	9·7	F5
,, 234 ..	0·35	8·8	F5
,, 387 ..	0·54	10·9	F2
,, 285 ..	0·34	9·5	F5
Σ 3123 ..	0·32	8·8	F5
H. I. 39 ..	1·49	24·7	F
γ Cor. Aust.	2·14	15·2	F8
4 Aquarius..	0·64	10·1	F0
γ Virgo ..	3·62	13·8	F
η Cassiopeia	10·10	54·0	F8

G.

Star.	Angular distance.	Hyp. distance.	Spectrum.
	″		
9 Argo ..	0·69	8·1	G0
85 Pegasus..	0·81	12·0	G
ζ Hercules	1·38	5·5	G0
η Cor. Bor...	0·89	9·1	G0
β 648 ..	1·04	11·4	G
Σ 2173 ..	1·06	12·4	G5
O Σ 298 ..	0·88	20·4	G5
ξ Ursa Maj.	1·92	11·3	G0
ζ Cancer ..	0·86	9·0	G0
O Σ 400 ..	0·57	15·3	G5
α Centaurus	17·7	17·8	G
ω Leo ..	0·84	10·7	G
ξ Bootes ..	4·97	42·1	G5
p Eridanus..	6·96	78·6	G5

K.

Star.	Angular distance.	Hyp. distance.	Spectrum.
	″		
β 395 ..	0·66	9·2	K0
Σ 3121 ..	0·62	17·5	K5
Melb. 8 ..	1·86	28·1	K2
70 Ophiuchus	4·56	29·7	K0
36 Andromeda	1·01	13·3	K0
μ_2 Bootes ..	1·44	31·0	K0

period? There are certainly no such pairs in the northern sky where they would most likely be found, and it is doubtful if there are such elsewhere. We are forced to assume that solar-type stars cannot exist in binary combination when their mean distance apart is much below five times the distance of the Earth from the Sun. In this connection the problem of the Cepheid variable stars may have some bearing; these are all solar-type stars which vary in brightness; their brightness increases when they are approaching the Earth, and *vice versa*. When it is assumed that the changes in their spectra can be dealt with upon dynamical principles—that is, when the changes are supposed to be due to the revolution of one body around the other—it is found that their distance apart is under one unit. The double star of known smallest mean distance amongst the G stars is ζ Hercules, and it is interesting to recall that although it has completed more than three revolutions since its discovery, and it is never a difficult pair to measure, its orbit cannot be found with any accuracy. Mr. T. Lewis, of the Greenwich Observatory, considers its period to be increasing.

It is unfortunate that so many of the short-period binary stars of Table I have not had their parallaxes measured, as they are almost certainly amongst the nearest stars.

Reflecting upon the above conclusions, and upon the failure to detect parallax in many stars of large proper motion, one is tempted to speculate both that gravitative power does not play a leading rôle in the movement of the stellar universe, and that the star clouds of the Milky Way are as near or nearer to the Sun than many of the proper motion stars are—or, in other words, that the stars of the Milky Way are faint, not because they are very distant, but because they are very small, and that many of the bright stars we see are really beyond the main girdle of the Milky Way. A very rough analogy would compare the small stars of the Milky Way to the zone of small planets travelling between the orbits of Mars and Jupiter, and the lucid stars to the major planets, the Sun again being near the centre of the system.

If we could carry out the operation of dividing a star into two equal masses as suggested earlier in the paper, would the spectrum of the new bodies be similar to that of the old body? This is hardly likely. It seems to be more probable that the spectrum varies with the mass or quantity of matter and its gravitative power or pressure. It would be too dogmatic to assert that if the spectra of two stars were absolutely identical, then the stars themselves would be absolutely identical in every other respect, but it is worth considering as a working hypothesis.

In the solar system, evidence of light-pressure is only exhibited by comets, and then only when they approach closely to the Sun. It is doubtful if there is any manifestation of this pressure when comets are at greater distances than five units. The planets, being composed of matter in a cohesive state, show no evidence of light pressure. If they were gaseous bodies of

very small density, they would no doubt react strongly to the Sun's light-pressure. It is therefore not unreasonable to suppose that when a double-star system is composed of two bodies of great luminosity and small density (such as the double star α Crux) light pressure plays an important part—it may even neutralise gravitative power, and oppose by its disruptive force the formation of close binary systems. Besides light pressure, it will probably ultimately be found necessary to consider the absorption or dispersion of atomic energies.

Speculation is so easy that it should not be encouraged; what is really wanted is further research and more facts.

APPENDIX.

FORMULÆ, ETC.

M = Gravitative power of the system, often for short, called the mass of the system,

R = Distance of the star from the Sun measured in radials, one radial being the distance indicated by a parallax of one second of arc; if π is the parallax in seconds of arc, then

$$R = \frac{1}{\pi}$$

N.B.—The parallax of a star is the angle subtended by the Earth's mean distance from the Sun as seen from the star. Hence one radial is equal to 206,265 times the mean distance of the Earth from the Sun.

a = Semiaxis major of a binary system measured in units of the Earth's mean distance from the Sun.

a = Semiaxis major of a binary system measured in seconds of arc. $\mathrm{T}a = \frac{a}{R}$, but as the tangent is indistinguishable from the arc at very small angles, we can write $a = \frac{a}{R}$

m = Magnitude of a star.

m' = Its magnitude, if brought to unit distance,

$$m' = m - 5 \log R.$$

The Sun's magnitude at any given distance is equal to 5 log R, so that at unit distance its magnitude is 0.0. This assumes that the Sun's magnitude, as seen from the Earth, is −26.57, and that the logarithm of the light ratio from one magnitude to another is 0.4 (See *Union Observatory Circular,* No. 5).

Conversely, if we put

$$m' = 0.0 = m - 5 \log R,$$

we have the distance R at which a star of magnitude m would shine as a star of magnitude 0.0, that is, as brightly as the Sun would at unit distance.

P = The period of a binary system in years:

$$M = a^3/P^2 = R^3a^3/P^2$$

θ = Annual angular motion in degrees or

$$360°/P.$$

Then we have

$$360^2 M = R^3a^3\theta^2,$$

or, by using logarithms,

$$\log \theta = 2.5563 + \tfrac{1}{2}\ (\log M - \log Ra).$$

If we can suppose that in stars of the same spectrum or constitution, the density and surface brilliancy are constants for every mass or volume, then for n times the diameter we have n^2 the surface and n^3 the volume, and therefore n^3 times the mass. If under these suppositions m is the magnitude for mass M, the magnitude for mass nM will be

$$m - \frac{5}{3} \log n.$$

If, again, a star of magnitude m is divided into n stars, each of the same emissive power as the original star, the magnitude of each would be

$$m + \frac{5}{3} \log n,$$

and the magnitude of the resulting cluster, omitting chance eclipses, would be

$$m' = m - \frac{5}{6} \log n$$

Thus, if $n = 2$, we have $\log 2 = 0.301$ and $m' = m - 0.25$.

We learn, incidentally, that the mass of a cluster remaining unaltered, the smaller the stars of which it is composed the brighter the cluster.

The cluster ω Centaurus, which shines as a hazy star of the 4th magnitude, is composed of 6,400 stars. If these could be combined into one star of the same emissive power, its magnitude would be

$$4 + \frac{5}{6} \log 6400 = 7.2,$$

so that it would be invisible to the naked eye.

So that the implication may not be missed, another example may be given. The Sun, if removed to a radial distance of 100 (parallax = 0″.01), would shine as a star of the 10th magnitude. A cluster of 1,000 solar-type stars at that distance, each

of the 15th magnitude, would have a total mass equal to that of the Sun's, and yet its combined light would result in the magnitude 7.5 or 2.5 magnitudes brighter than the Sun at the same distance. In all but the very largest telescopes, such a cluster would be irresolvable into stars.

SUMMARY.—Few double stars have gravitative power so great as that of the Sun. Gravitative power is small in stars of spectral classes B and A, moderate in F, and large in G and K. It seems to be absent in classes Oe and M. There appears to be a limiting distance below which double stars cannot exist, and for solar-type stars this appears to be about five times the Earth's distance from the Sun. Very faint binary stars are only found in proximity to bright stars. It is suggested that light-pressure may partly or wholly neutralise gravitative power in stars of great luminosity and small tenuity.

CARBON BISULPHIDE AND PLANT GROWTH.—In 1911 E. B. Fred, Agricultural Bacteriologist, in the Agricultural Experiment Station of the University of Wisconsin, published data to show the beneficial effect of carbon bisulphide on the soil flora.* The increased plant growth following on the addition of carbon bisulphide is in many cases enormous, a small application often causing an increase in yield from 100 to 200 per cent. But in some cases carbon bisulphide not only fails to cause an increase in plant growth, but, on the contrary, has caused a decrease. The author of the former paper accordingly studied some of the factors that might influence this peculiar action of carbon bisulphide, and has recently published his results in the *Journal of Agricultural Research*.† The addition of carbon bisulphide to soil, he states, exerts a decided effect on the fauna and flora of the soil. This is characterised by a temporary reduction in the number of micro-organisms. Later, an enormous multiplication of bacteria takes place, and an almost parallel increase in production of by-products or soluble nitrogen is noted. The ammonia-content seems to follow the curve of bacterial growth, and later gives way to larger amounts of nitrate. From the evidence it seems that carbon bisulphide in soil produces an increase in soluble compounds of nitrogen and sulphur. It is clear, however, that carbon bisulphide does not act alike in all soils, or toward all crops.

* *Centralblatt für Bakteriologie* **31**, 185-245.
† (1916) **6** [1] 1-20.

THE INFLUENCE OF THE CLIMATIC AND TELLURICAL FACTORS ON THE DISTRIBUTION AND SPREAD OF CERTAIN ANIMAL DISEASES, WITH SPECIAL REFERENCE TO THE CONDITIONS OCCURRING IN SOUTH AFRICA.

By D. Kehoe, M.R.C.V.S.

It is the belief of the writer that the interest attached to the collection of results obtained through specialised researches, and the co-ordination of these in such a way as to point out their influence on conceptions regarding the relationships existing between certain causes and certain effects, is in itself sufficient justification for presentation of a paper of the nature of the following to the members of an Association as ours, consisting as it does of persons who are interested not only in the advances made in their own particular branches of science, but who are also interested in learning of general advances made in fields outside of their own. If, however, justification were needed for the selection of the subject, it is to be found in the marked interest shown by the majority of the members of our community in South Africa in the marked prevalence of certain of our stock diseases under the rather unusually wet climatic conditions prevailing during the early part of this present and latter part of the past year. At that time one was often asked for an explanation of the state of affairs existing in regard to the prevalence of these diseases, and equally often limitations imposed by time enforced a brief reply to such queries. In the paper which follows, however, an attempt is made to furnish a general reply to questions of this nature, although even here the same limitations as those before referred to do not allow of any more than the main points to be dealt with and the outlines of the subject to be indicated. It is, however, hoped that these outlines given here may furnish some ideas of the relationships existing between certain diseases and the environment in which they occur, and if this paper should stimulate an interest in the subject in those who, having no specialised interest in disease problems, yet have that general interest in all problems affecting the welfare of the community which is demanded from every thinking individual, the purpose of the writer will have been fulfilled.

With these remarks we shall, then, first proceed in an introductory fashion to a more general consideration of the subject, later coming to examine the matter in fuller detail.

Now, many of our South African stock diseases are of such a nature that they happen to be included under the headings of tropical or subtropical diseases, and here we meet with two terms which in themselves suggest a classification based on climatic distribution. If we enquire into this grouping more closely, however, we find that a classification of this nature is one founded on considerations of convenience rather than of accuracy, which

latter is only found in a grouping of diseases according to their ætiology.

If, to make this point clearer, we enquire still further into the matter, taking the collection of animal diseases met with in South Africa to illustrate our remarks, we are met by the fact that certain of the diseases on our list occur equally commonly in other parts of the world situated in more temperate and colder regions. Examples of such diseases are the bacterial affections, anthrax, blackquarter, glanders, one due to a virus of the filterable type, namely, contagious pleuro-pneumonia of bovines, and numerous parasitic helminthic affections. It may also be recalled that a disease fortunately not on our present list, but still existing in other parts of the world and in some places under the conditions referred to immediately above, namely, rinderpest, when introduced into this country some years ago, soon showed by its rapid and wide spread that the conditions of this subcontinent were very favourable to its existence.

On our list, however, we note the existence of a certain collection of diseases exemplified amongst the groups Babesiosis, Theileriasis, Anaplasmosis, Nuttalliosis, Spirochætosis, and Trypanosomiasis, the causal agents of which are protozoan organisms, and by a disease known popularly as heartwater, due to a filterable virus. Now, a peculiarity common to all these diseases is found in the requirement for their transmission from one animal to another of the intermediary agency of some animal carrier, this being either an arachnid (tick) or an insect (fly), and it is to this group of diseases transmitted indirectly in this manner, that we particularly refer when we speak of the tropical or subtropical diseases of stock. That diseases transmitted in this way are, however, not peculiar to the tropical or subtropical climates is soon proved in examining the distribution of one of them, namely, redwater, a tick-borne disease of cattle of very widespread occurrence, and found under the varying climatic conditions of such countries as Africa, North and South Americas, India, East and West Indies, Australia, Caucasia, Italy, Turkey, Roumania, Germany, France, Finland, Denmark, Great Britain and Ireland and other places; but that as a group they have come to be specially regarded as diseases of tropical or subtropical climates is simply dependent upon the fact that it is in these climates they tend to be most prevalent, the explanation of this being that it is in regions situated in these climates their animal transmitting agents find the environment best suited to their existence and development. This question of suitability of environment to the requirements of their transmitting agents is thus the chief factor regulating the distribution of these tropical or subtropical diseases, and that this environment should be so favourable to these carrying agents is not difficult to understand when we remember that outside of food supply the principal conditions demanded by them for their existence is the presence of a suitable amount of heat and moisture, both of which are supplied in optimum degree in tropical and sub-tropical regions.

This question of environment we may examine in a little more detail, as it is connected with the later part of our subject. If we do so, we soon meet not only with the importance of the climatic factors of sunshine and rain acting as the direct sources of supply of the warmth and moisture necessary in the above connection, but also with the importance of other factors which, in the title of this paper have been referred to as tellurical. Under this latter term we recognise all those peculiarities in regard to character and nature of soil, vegetation, geological formation, minor surface relief and water supply of any given locality, and the importance of these in regulating the retention and distribution of the heat and moisture supplied by the climatic elements is obvious. In the following paper, however, the attempt is made to make an additional importance of these conditions more evident in the present connection, and this by pointing out how through soil or vegetation, or collections of water in the form of rivers, streams, pools, marshes, vleis, pans, etc., or a combination of these, they may provide habitats suitable to the existence and development of either a transmitting or intermediate host of a disease-causing organism, or a disease-causing organism itself.

These remarks bring us nearer to our main subject, and it is unfortunate that time and space do not allow of these general considerations being further pursued. If they did, we might have dealt with the interesting part that civilised man has played in the distribution of tropical and subtropical diseases through his habits, and the changes he has produced in the tellurical conditions of the countries where they occur, by the methods he uses in opening up and developing these newer lands and furthering his agricultural and pastoral pursuits within them. We might also have pointed out how the special problems which these diseases offer have atttracted a certain body of workers to study them, and how the results of their researches have come not only to give the terms tropical and subtropical diseases the significance they possess in medicine at the present day, but also to furnish man with measures for combatting these diseases, thus giving him further scope in influencing their distribution.

These considerations, however, would furnish materials for several papers in themselves, and hence we must leave them in proceeding to the more detailed examination of our subject. In doing this latter the writer may mention that he does not intend to enter into a description of the climatic and tellurical conditions existing in South Africa—conditions with which the reader is no doubt well acquainted—but, taking them as they are, intends to attempt to explain their influence on the spread of disease, illustrating this in taking as examples animal diseases commonly occuring in this sub-continent. For this purpose a convenient grouping of the types of diseases dealt with will be necessary, and perhaps the most suitable procedure is to group them under the four headings of—

1. Bacterial diseases.
2. Tick or insect-borne diseases.
3. Diseases caused by helminthic parasites.
4. Diseases due to toxic plants.

Of the first group it is not intended to say very much, and space only permits of one example of this type being dealt with. This example, however, has a general interest, and is met with in the disease anthrax.

In anthrax we have an example of a bacterial disease of practically world-wide distribution, and to which all of the domesticated and many non-domesticated animals are susceptible. The organism responsible for the disease is a bacillus known as the *Bacillus anthracis*, a facultative parasite of aerobic habits.

It is known that the disease can be contracted through the channels of inoculation and inhalation, but the commonest route of infection in the lower animals is apparently ingestion. Infection through this channel follows the ingestion by the animal of either food or water containing the organism, or more particularly its spores. The importance of foods grown on infected areas or special foodstuffs prepared from contaminated material serving as vehicles of infection is recognised in this connection, but the part played by infected pastures acting as sources of infection to the animals grazing over them is the aspect which is of most importance for our present consideration.

In many parts of the world the disease is regarded as being associated with certain localities, and these frequently resemble each other in being places situated in the neighbourhood of water or in the soil being of a moist or damp character. Instances of such localities are marshes, swamps, near natural water pools, along river banks, and on plains which are periodically flooded, such as recognised flood-plains, and river deltas. These are widely-recognised facts, but in order to explain them and also other observations made later on, it is necessary that we should learn something of the biology of the bacillus causing the disease, and hence we may pause here in order to do this.

A great deal is known about the biology of this bacillus, but we will only deal with the points of greatest importance to us. The *Bacillus anthracis* is an oganism which is a facultative parasite—that is to say, it is an organism capable of existing or leading a saprophytic existence outside the animal body, two of its common habitats under these conditions being soil or water. In cultivation it is an organism requiring free oxygen for its development, hence it is referred to as being aerobic in character, and it is also known that the bacillus which represents the multiplicative phase of the organism is capable of multiplying at temperatures between 12° C. and 45° C., the optimum temperature being about 32° C. to 35° C. The bacillus itself is not very resistant to adverse circumstances, behaving as most ordinary bacteria do under these conditions. It is soon destroyed

by ordinary chemical or physical germicides, and can only withstand dessication for a matter of days.

On the other hand, we know that under certain conditions the bacillus is capable of giving rise to a vegetative form known as a spore, which is extremely resistant indeed. Two conditions are necessary for the formation of these bodies: one of these a supply of free oxygen, the other being a suitable temperature: the optimum degree of the latter being about 30° C., although their formation can occur at any temperature inside the minimum limit of 16° C. and the maximum limit of 42° C. That they are extremely resistant has been proved from their behaviour when subjected to the action of the usual chemical germicides, or when under the influence of physical agents, such as heating to a high degree, and their resistance to desiccation is remarkable, inasmuch as they have been known to survive in this dried condition for over ten years. Putrefactive changes are not inimical to them, and here again they differ from the bacillary form, which is soon destroyed in the presence of these changes.

These spores are not formed by the bacillus when it is present in the bodies of animals suffering from the disease, nor are they formed after the death of the animal provided the carcase is unopened, owing here to the lack of free oxygen necessary for their production. Under these latter conditions decomposition occurs in the usual way, and the bacillary form of the organism is soon destroyed in the presence of the putrefactive changes then occurring.

On the other hand, when the body of an animal dead from the disease is opened up soon after death, the bacilli escaping with the blood and other body fluids and organ juices soon find the supply of oxygen necessary for spore formation, and spores are rapidly formed. If now, as very commonly happens, the carcase is opened on the pasture or veld, it is not difficult to see how the soil and perhaps water may become infected through material containing the organism and its spores. Infection of soil has been known to follow the use of manures prepared from contaminated hides or bones, or following irrigation by water from knackeries or tanneries where infected hides had been dealt with, but under natural conditions, and especially in this country, the commonest method of original soil infection is probably that above mentioned, namely, the opening up of carcases on the veld soon after death. Once the soil is infected it is easy to understand how this infection is maintained through the presence of the spore, which is so resistant, and which, as mentioned above, is capable of surviving, even under desiccation, for ten or more years. It is also believed that in warmer countries the organism cannot only exist in the soil, but even multiply when a sufficiently suitable temperature is present.

These facts will explain, in part, why certain areas may come to be regarded as "anthrax localities," but we must now note some facts in regard to the association of the spread of the dis-

ease with water. This association is one which has long been recognised, and reference has been made to it previously in this paper when speaking of the prevalence of the disease in the neighbourhood of swamps, river courses, pools, etc. Numerous observations have been made in this connection, and the importance of flowing water in distributing anthrax spores or of stationary collections forming resting-places for them has been referred to. It would be interesting to look into these observations here if we could afford to do so, but as we cannot, reference may be confined to one or two of them. One that might be specially mentioned comes from a worker in Hungary, who, having to deal with an outbreak of the disease in cattle, came to the conclusion that the source of infection must have been the drinking water. The cattle in this case were watered from pools formed along the bed of a river which had run dry following a long period of drought, and it is noteworthy that the cattle which died were those which were in the habit of drinking last from the pools after the other members of the herd had stirred up the mud from the bottom. Having come to the conclusion that the drinking water was the source of infection, he made a bacteriological examination of samples of the water and also the mud from the bottom of these pools, and as a result of this examination, and by using special methods, he was able to prove the existence of the anthrax organism in these samples.

Another observation which is interesting to us, though not so conclusive as the last, is made by Smith in referring to the occurrence of the disease in India, which, to use his words, is a notorious anthrax country. He refers to the soil conditions there being suitable for the development of the disease, and points out that the diseases is seasonal. According to him, the disease is practically limited to the wet season, and almost invariably associted with recent rainfall. The explanation he suggests for this is that the rain-water acts as a distributing agent for the anthrax spores, washes these into the pools formed during the rains, and that animals become infected from food washed in these pools. He states that in India it is a practice to wash grass or hay in pools before feeding it to animals, and that with abolition of this practice through the efforts of the Veterinary Department, a great reduction in the number of anthrax outbreaks has occurred.

Now these particular observations have been introduced and stress purposely laid on them here because of the apparent importance which water has on the spread of the disease in South Africa. In the Transvaal, whilst the disease is met with all the year round, it is in the wet summer months that it is most prevalent, and its association with pans or other collections of water where animals are watered has been noted. That similar conditions are met with in other parts is evident. Mr. Dixon, Government Veterinary Surgeon of Cape Province, states that in that Province the disease is widespread, the only area in which it is not endemic being the Karroo, and that it shows a seasonable prevalence, the greatest incidence falling within the summer

wet season. He also specially refers to pans and edges of vleis in Griqualand West as being recognised hotbeds of the disease. In the Orange Free State it is also, according to information received from the Veterinary Department there, a disease of the wet season, and it is said to have been usually prevalent there during this year.

Again the connection between rainfall and the spread of the disease can be brought out in the unusual prevalence of the disease on the Witwatersrand area of the Transvaal during the early part of this year, the rainfall at this time being unusually heavy.

All of these facts, then, seem to point to the great importance of water in the spread of the disease in South Africa, and it may be stated as the opinion of the Veterinary Research Division that collections of water, such as pans, etc., from which animals are watered, very probably play a large part in the dissemination of the disease in this country, these collections of water being probably infected through the rain washing into them anthrax spores derived from soil infected in the way already indicated. That water may possibly also be important in spreading the disease in another way in this country is shown by Theiler's remarks in writing about the outbreak of anthrax amongst ostriches in the Oudtshoorn district, in which case he thinks that the water used for irrigation purposes must be held largely responsible for the spread of the disease in that place.

These, then, are just a few of the points we meet with in studying the effect of climatic and local conditions on the spread of one disease of the bacterial group. Black-quarter is another disease with a very interesting distribution and occurrence we might have dealt with, and two other diseases connected with soil, such as malignant œdema and tetanus, we might also have briefly referred to if we were not forced through consideration of time to drop our considerations of the bacterial diseases at this point.

Let us remark, however, in passing, that in regard to the actual conditions of life in the soil of disease-producing organisms little is really known, although our knowledge of their behaviour in the animal body and in culture media is extensive. It is only within the last few years that the importance of the protozoa of the soil as agents influencing the prevalence and activity of soil bacteria has been brought into prominence through the researches instituted by Russell and Hutchinson. This importance is one which, owing to the recent nature of the study, has not yet been grasped in all its details, but it is to be expected that in the future the work of those who specialise in the study of soil biology will throw much light on the life-history of those bacteria in which we are particularly interested.

Leaving, then the bacterial diseases, we proceed to the second group, taking first into consideration the diseases carried by ticks.

Tick-borne Diseases.

When we come to look at the list of diseases transmitted in this way, we find that in South Africa they are well represented. Amongst the babesioses or piroplasmoses we find diseases of cattle due to *Babesia bigeminum* ("redwater") and *Babesia mutans* (producing a form of so-called "gall-sickness"). In the dog *Babesia canis* is responsible for "biliary fever" or "malignant jaundice" of this species. The Theileriases are represented in the East Coast fever of cattle, and in the same species of animal occurs a disease anaplasmosis, due to a parasite described by Theiler as *Anaplasma marginale* or its variety *centrale*. In "biliary fever" of equines, we have Nuttalliosis represented, whilst spirochætosis is met with in cattle and other species and in "heart-water" of cattle, sheep, and goats we have a disease due to an organism of the filterable variety.

In this class of diseases we find from the biological point of view an extremely complex state of affairs existing in the inter-relationships between the disease-causing parasites, their vertebrate hosts, and their definitive invertebrate transmitting hosts. The disease-causing parasite needs the presence of both types of host for its full development, although the forms met with in one host, say the vertebrate, are capable of existing for long periods in the absence of the other invertebrate host, and *vice versa*. Hence a study of effect of climate and local conditions on the spread of these diseases might include a study of these conditions in their influence on the distribution of both types of host. In this paper, however, we confine our attention solely to the study of the effect of these conditions on the life history of the invertebrate host, the tick. In order to do this, we must first briefly enquire into the life-history itself, the essentials of which are as follows. The mature female tick having engorged herself with the blood of the vertebrate host, and having been at the same time fertilised by the male, drops from her host to the ground, and after a varying period (pre-oviposition period) lays her eggs. These eggs sooner or later hatch, and from each of them emerges a six-legged or hexapod larva which must undergo a moult or ecdysis before passing to the next or nymphal stage. The nymphal stage is represented by an eight-legged or octapod form, which resembles the adult except that it is sexually immature, and it must also undergo an ecdysis before it can pass to the final stage of the adult or imago. Thus we recognise four stages in the life-history, namely, the egg, the hexapod larva, the octopod nymph, and the imago or adult male or female.

The conditions under which these different stages occur vary, however, with the different species. In one species, for instance, the larva hatched from the egg having climbed up a grass blade, and thence passed on to its host, the tick may then pass the rest of its life-cycle up to the adult stage on this same animal. This occurs, for example, in the case of the "one-host" group of ticks, an example of which is found in *Rhipicephalus decoloratus*. In another case the larva, gaining its host

in the same way, may engorge and moult to the nymphal stage on the host. The nymph then engorged drops to the ground to moult to the adult stage, when a new host has again to be found. Species with a life-cycle of this kind are included within the "two-host" ticks, and here an example is *R. evertsi*. Another condition of affairs still exists in those cases where the tick drops from the host, first between the larval and nymphal stages, and then again between the nymphal and adult stages. These ticks have thus to find hosts first as larvæ, then as nymphæ, finally as adults, and hence are known as "three-host" ticks. An example of this kind is *R. appendiculatus*.

To learn now something of the effects of climatic and tellurical factors on the development of some of these species in South Africa, we shall take as examples the blue tick *Rhipicephalus decoloratus*), the brown tick (*Rhipicephalus appendiculatus*), and the bont tick (*Amblyomma Hebraeum*).

The first of these is perhaps the most common South African species, and is very widespread in distribution. Fuller, speaking of it in the Cape Province, says that it is the most widely-distributed tick in that Province, and Theiler, speaking of the Transvaal, says that it occurs everywhere, but is certainly less frequent on the high than on the middle and low veld. It is known to be responsible for the transmission to cattle of the protozoan parasites causing redwater, anaplasmosis and spirochætosis, and is a "one-host" tick. The moults between larval and nymphal stages and between the latter and the adult stage are thus passed on the animal host, and because of this fact little or no variation is met with in this portion of the life-cycle when summer and winter seasons are compared. The usual time occupied in both seasons is about 23 days. The effects of climatic conditions are, however, seen when we examine that portion of the life-cycle between the time when the female drops from the host and the time when the larvæ emerges from the eggs which she has laid, and to illustrate this point we may quote from Fuller's and Theiler's observations in this respect.

The former says:

> The female, after dropping from the host, starts laying in from five days to two weeks in summer, while in winter at Capetown, at a temperature 65° to 70° F., she delays until the third or fourth week has passed. Similarly the incubation period of the egg varies from three weeks to three months. At a temperature of 85° to 90° in the incubator, hatched eggs have been obtained in four weeks from the dropping of the mother tick, which shows heat hastens development. Some moisture appears necessary during the incubation period, as several batches of eggs kept in dry boxes have shrivelled and failed to hatch.

And again he says:

> The entire life cycle may be passed in two summer months, but, in fact, probably seldom takes less than two and a half or three. There is a possibility of three broods a year in our Cape climate, and a probability of at least two broods.

In the climate of the Transvaal and in summer Theiler has noted that the female usually begins to lay in five days after dropping from the host, but in winter several weeks may elapse

before she commences this operation. The eggs laid usually hatch in three to six weeks, with an average of 36 days, in the warmer season, whilst in winter many weeks may pass before hatching occurs. He also remarks:

> The complete life-history requires, under the most favourable conditions, little more than two months.

So much for the blue tick here, and now let us consider our other examples. Both of these are "three-host" ticks, and having thus to pass the periods between larva and nymph and nymph and adult on the ground, it is easy to see that the climatic and tellurical conditions will affect their life-histories much more than in the case of a "one-host" tick such as the blue tick.

Taking first the brown tick (*R. appendiculatus*), which is one of a number of species capable of transmitting East Coast fever, and probably the commonest agent in doing so, we shall quote Theiler in regard to its life-history in the Transvaal; but it should be remarked that observations in regard to the effect of climatic and local conditions on the development of this tick have also been made in the Cape Province by Lounsbury. Theiler, speaking of it, says:

> It is principally a summer tick, during which time it is found on various domesticated animals . . . . and prefers as its habitation warm stretches of the country. It is abundant in the low veld, less frequent in the middle veld, and is very rare, often entirely absent, on the plateau of the high veld, but it may be found there where in protected valleys the vegetation grows higher.

The influence of climate on its development he has shown in observations which may be condensed as follows. The female tick, after dropping from the host, may commence to lay eggs in six days, and in the summer these may hatch in an average time of 28 days (the shortest period recorded being 13 days), whilst in winter hatching may be delayed for several months. The larvæ now pass on to their host and there engorge, an operation which may only occupy a period of three days. Having done this, they drop to the ground to moult to the nymphal stage, which moult occupies a period of 21 days on an average in summer, whilst in winter it is increased in length. The shortest period recognised in this part of the life-history was 16 days under the most favourable conditions. The nymph now engorges in the same way, and in about the same time as the larvæ has done, and then again drops to moult, and in this case the average time occupied was about 18 days. Theiler estimates that the whole life-cycle of this tick may thus occupy about 73 days in summer, and under the most favourable conditions, whilst in winter he believes that it may take over six months for its completion.

The other tick of the "three-host" group, namely, the bont tick (*Amblyomma hebræum*), has been taken to illustrate a point referred to later on. This tick is, as Lounsbury has shown, the agent responsible for the transmission of that disease of cattle, sheep, and goats known popularly as heart-water. Speaking in

1899, Lounsbury said that it was known to occur from Humansdorp and Uitenhage in the Cape Province, eastward to Natal, and inland for about 50 miles from the coast, and that it probably occurred for a long distance up the East Coast. He also stated that it was recognised prior to 1835 in Lower Albany, being then regarded by the farmers there as a curiosity. In the Transvaal Theiler has pointed out that this tick is limited to the bushveld proper, occurring only in those parts of the low veld where real bush is met with, and not appearing in the middle veld. This point will again be referred to, and it is chiefly because of this limitation of distribution that I have introduced this tick here, but at the same time it is very interesting to note certain points in connection with its life-history.

Thus we may mention that, according to Theiler, the period occurring between the dropping of the engorged female from the host and the laying of eggs may vary from two weeks in summer to three months or more in winter time, and the eggs deposited may hatch at the earliest in summer in about 10 to 11 weeks, whilst in winter this may only occur in as many months. Lounsbury states that if kept too dry and warm, the eggs may cave in all along one side and shrivel up, but that it takes very little moisture to keep them alive, and that hatching does not depend on rain, as is often popularly believed. The period occupied by the moult from the larval to the nymphal stage is from 25 days to four months under natural conditions, according to Theiler, and Lounsbury has shown that where this process was artificially hastened in the incubator the period occupied was reduced to 16 days. In two batches of ticks kept in a sunny, sheltered place during the daytime, and placed indoors at night, this latter observer noted that moulting at this stage did not occur until seven winter weeks had expired, and he therefore believes that under veld conditions in the Cape Province the period must vary with season and situation probably from one to three months. The engorged nymph in moulting to the adult stage may take, according to Theiler, from about 25 days in the summer and 160 days in the winter in the Transvaal, whilst in the Cape Province Lounsbury noted that the period was variable, and that whilst in one individual of one batch of ticks the nymphal skin ruptured as early as the eighteenth day, in another batch this only occurred about the eleventh week.

These facts will suffice to show the importance of climatic and tellurical factors in affecting the development of these ticks, and similar observations pointing to the great importance of heat and the lesser importance of moisture on tick development have been made on the same and numerous other species in many parts of the world, and largely in Europe and America.

Enough, however, has been said to explain the points which are of special interest to us in considering the prevalence of the diseases transmitted by these arachnids. It is, for instance, now not difficult to understand the greater prevalence of tick-borne diseases during the months of summer and autumn as compared

with the winter months. During the former time the warmth so necessary for their development is supplied to them in greatest degree, and hence the ticks increasing in activity and number, the greater prevalence of tick-borne diseases is only to be expected granted that the suitable vertebrate hosts are present. We can also understand how it is that ticks are generally more prevalent in the warmer, low-lying bushveld and coastal belts than in the middle and high veld areas, a distribution which, as Theiler remarks, the South African farmers recognised when they applied to the tick the generic name of *Bosluis*. If we take a disease such as redwater, transmitted by the blue tick, we can explain why that, although cases of the disease are met with all the year round, they are more markedly prevalent in the summer and autumn months, and we also can explain its greater general prevalence in low-lying, warm areas of the bush veld or coastal regions, as in the Transvaal low veld, in Natal, and in the eastern, southern, and south-western portions of Cape Province, when these areas are compared with the higher veld areas of the Transvaal, Orange Free State, North-Western Cape districts, and Basutoland. It is recognised that other conditions affecting the distribution of the disease, such as trekking from high to low veld pastures, will influence the spread of the disease, but these considerations and others, such as the non-occurrence of the red-water in alleged susceptible cattle when placed in contact with alleged infected cattle in the presence of the blue tick in the Karroo region of Cape Province, must be left over for another time.

Reference has already been made above to the brown tick in considering the effect of climate on its distribution and life-history, and we might, if we wished, show how our knowledge of the distribution and occurrence of East Coast fever fits in with what we know of the habits of this and other ticks transmitting the disease, but it does not seem necessary to do so here. One observation may be mentioned, however, as, if correct, being still unexplained. It has been said that when the disease was generally prevalent in the Transvaal some years ago, it tended to disappear very quickly from the high veld areas when introduced there. It was also pointed out that this could not be explained as being due to the absence of the transmitting ticks, since, although the brown tick is rare in this region, the red tick is also to be found there. Theiler does not believe that the cold conditions of the high veld can be held directly responsible for this occurrence, and one suggestion put forward was that it perhaps depended on the fact that regulations restricting the disease were more strictly complied with in the high veld, where the native population is smaller than in the low veld regions, and in which latter places illicit movements of animals by natives was very often practised. Further explanation is, however, necessary, but it is interesting that Theiler showed, when experimenting in this connection, that infected brown tick nymphæ, kept for half an hour at 0°C. every day for three weeks, were still infective in

the adult stage, and that the only effect of this temperature was to increase the period occupied by the moult occurring in this change. He also studied the influence of low temperatures on the larvæ of the blue tick, and it is interesting to record the results obtained as showing the effects of the temperatures used. He noted that *Rhipicephalus* larvæ did not die when exposed to minus 18° C. for 15 minutes, but that exposure to the same temperature for 30 minutes did cause their death, and also that whilst the larvæ of the same species resisted a temperature of minus 5° C. for 24 hours, the majority of them died when subjected to the same temperature for 48 hours.

We may, however, finish now with this part of the subject in referring again to that disease of cattle, sheep, and goats known as heartwater, and transmitted by the bont tick. In speaking of the habits of this tick, it has been mentioned already that in the Transvaal it is in the bush veld that it has its home, and does not seem to find the conditions of the middle or high veld suitable for its existence and development, although it has been introduced into these areas on several occasions by cattle returning there in summer from their winter bushveld pastures. The high-veld farmer has long ago had these habits of the bont tick impressed upon him as a result of his practice of transhumance in trekking with his stock in winter to the low bushveld pastures, where he meets with the disease it transmits. He has also long recognised that in trekking back to the high veld in summer he leaves the disease behind him, but it is only as a result of comparatively recent researches that we now find an explanation for these observations. Here, then, again we have had an example of how climatic and tellurical conditions will influence the distribution of a disease through the influence exerted by them on the transmitting tick agent, and as the effects of these factors on ticks and the diseases carried by them have been sufficiently indicated, we may now pass to consider how these same factors may influence the diseases carried by insects.

Insect-borne Diseases.

It may here be expected of the writer that he should deal in some details with such diseases as are well known to be fly-borne, examples of which are to be found amongst the trypanosomiases, but let it here be stated that such is not his intention. What has already been written in other places concerning the bionomics of the flies transmitting these diseases is enough to fill several large-sized monographs, and the writer wishes more particularly to refer to certain well-known South African diseases which, though not definitely known to be insect-transmitted, are suspected of being carried in this way. For this purpose special reference will be later made to such well-known South African diseases as horse-sickness and blue tongue of sheep, but, in passing, brief reference may be made to trypanosomiasis as far as this portion of South Africa is concerned.

It is, for instance, interesting to note that in Zululand, where

Bruce made his original observations, the disease is still existent. Following the outbreak of the epidemic of rinderpest which, entering the northern portion of South Africa in the years 1896 and 1897, swept down through this country, the number of *Glossina* flies is said to have decreased in Zululand simultaneously with the decrease in number of the game animals killed there by the epidemic. Since the time, however, that the rinderpest disappeared, both the "fly" and game have increased in number up to the present day. In the Transvaal, on the other hand, and following the same epidemic, trypanosomiasis and the "fly" carrying it disappeared entirely from the east portion of this territory. Previous to the rinderpest the fly was well known in this part of the country, and that it may have had a wider distribution is indicated by a fact referred to by Theiler, which is that on an old map of the Transvaal, published by Jeppe many years ago, the country above a certain line is marked as infested with "fly." This line has its lower extremity situated near the junction of the Marico and Crocodile Rivers, and from here runs north-east through the Waterberg district up to the Limpopo. Theiler also mentions certain "voortrekkers" as having told him that 30 or 40 years ago they met with the "fly" north of Pretoria, and not far from the Magaliesberg. Into this point, however, and also the explanations suggested to account for the disappearance of the "fly" from the North-East Transvaal, we cannot further enter here, but these remarks, however, made here chiefly because of their general interest, will also show that, whatever parts certain hosts may play in determining the distribution of flies of the genus *Glossino,* the climatic and tellurical conditions of the North-East Transvaal were suitable to the existence of the "fly" there some years ago—and they may still be so—and that in Zululand they are suitable to the fly even at the present day.

Let us then now pass from trypanosome diseases and proceed to consider the two other diseases needing no introduction in South Africa, namely, horse-sickness and the disease of sheep known as blue tongue or malarial catarrhal fever.

To commence with horse-sickness, we may note that it is not a disease peculiar to Southern Africa, but has also been recorded along the East Coast as far upwards as the Italian Colony of Eritrea; in the Soudan; in some places towards more Central Africa; and on the West Coast up to St. Paul de Loanda. So far, it is not known further north on this latter coast—as, for instance, in the Congo region—but its prevalence in what was known as German South-West Africa has been brought home forcibly this year through the numbers of equines dying from the disease during the operations of the Union forces in that territory.

It has been noted in the areas where the disease is present in South Africa that it does not present the same degree of severity in every year, and certain epizootic ravages have even become historical. One of the earliest of these referred to is

that of 1780-81 in Cape Colony. Others are those of 1801, 1819, 1839, 1854-55 in Cape Colony, of 1888 in Natal, of 1891 and 1892 in Cape Colony again, and 1893-94 in the Transvaal and Orange Free State. In the Cape in 1854-55, according to Edington, the number of horses alone dying from the disease was 64,850, representing a value of £525,000, at this time a commission being appointed to enquire into the disease; and in the epidemic of 1891 and 1892 it was estimated that 13,979 horses and 149 mules succumbed.

Apart, however, from such great epizootics, it is recognised that in certain localities the disease shows a well-marked annual seasonal prevalence, although in certain tropical areas and also subtropical belts the disease may be met with all the year round. In the first-mentioned localities the greatest prevalence is met with in the warm wet months of summer and early autumn, and the areas of these localities which are most affected are the low-lying ones.

It must be pointed out, however, that it is not the absolute altitude of a region that is so important in this connection, but rather the comparative altitude, and that the disease may occur in the low-lying portion of a region which has an elevation above sea-level of even several thousand feet. It is true, generally speaking, that very high altitude, such as that of the Witwatersrand, may, in ordinary years, give a certain amount of protection against the disease, but that even such places are not protected by their altitude in years when the disease is very prevalent is shown by the heavy mortality occurring on the Rand area during the years 1907 and 1915.

The more important factors in determining the presence of the disease, however, seem to be the presence of water and also moisture. That this is so is indicated by a number of facts such as the following. This disease outside of certain regions before referred to shows its greatest prevalence during the wet summer months, and then it is most common in the lower lying areas and in the neighbourhood of rivers, spruits, vleis, pans, or dams. It is known also that the prevalence of the disease varies with the quantity and distribution of the rainfall—that the earlier the rains appear, the earlier the disease appears. It has also been remarked that if two seasons in which the total rainfall is about equal in amount are taken, the disease is not so prevalent in the one in which the precipitation is fairly equally distributed throughout the season, as in that in which the maximum rainfall occurs inside a short period of time—an occurrence noted as more usually happening in the later part of the horse-sickness season. It is also generally known that the ravages of the disease in any given horse-sickness season cease with the appearance of the first frost, and that cases occurring after this time are the extremely rare occurrences, which, however, have been met with.

These are facts which are generally recognised, and that a number of them were known to the farmers of South Africa even as early as 1811 is shown in a letter quoted by Edington

and from the traveller Burchell, who visited this country about that year. Writing at that time from the Roggeveld Mountains, he says:—

> The Hanteberg district, lying in the direction of north north west from the Roggeveld mountains, is said to be very high land and remarkable for being one of a few situations in this part of the country where horses are not liable to the horse-sickness which rages during the summer season, and annually carries off great numbers.

Speaking of Klaarwater, he stated:

> After the months of October no frost is expected for seven months, but in the morning of May it is always found to return, and is the signal for the return of the Boer's horses from the Roggeveld, whither they are sent in January to avoid the *Paardeziekte*, a fatal distemper to which they are liable in the hotter months. Those who object to sending their horses such a long distance from the settlement are content to run the risk of keeping them in the Landsberg, an elevated mountainous country lying in north north west direction. This, however, not being so cold as the Roggeveld, is less safely to be depended upon. It does not seem that the distemper acquires its full force until the beginning of February, but after then the lower districts of the whole of the extra tropical parts of South Africa are as far as my experience enables me to speak, subject to its baneful effects. Experience has shown that the first frost, whenever it happens, fortunately puts a stop to its further ravages.

Thus wrote Burchell over a hundred years ago, paying a high tribute to the observation of the Dutch farmer even at that time.

It has, moreover, been observed that a certain amount of safety is conferred on horses in bad districts by stabling them during the night, and from shortly before sunset until some time after sunrise.

If we were now to consider in detail the disease known as blue tongue, we could bring out exactly the same points as we have noted in regard to horse-sickness. It also is a disease of the wet summer season and of low-lying places near the vicinity of water. It is rarely met with after the first frost has appeared until the next summer sets in again, is rare in sheep stabled in closed sheds between sunset and sunrise, and it is a disease especially prevalent in exceptionally wet seasons. The similarity between the conditions under which the diseases occurred is, indeed, so striking that the Boers observing it, and also noting that in certain cases of horse-sickness the tongue assumed a slightly bluish colour, came to the conclusion that both diseases were really due to one causal agent acting on two different species of animals. The latter conclusion has, however, since been shown to be wrong by proving that each of the two diseases is due to a distinct and separate filterable virus.

Here, then, we have two diseases, influencing the distribution and prevalence of which the climatic and tellurical factors are seen to be of extreme importance; hence it is of especial interest to see if we can explain the reasons for this influence. Such an explanation, however, cannot be found in exactly the same way as we have seen in the cases of the other diseases hitherto considered. In those cases we were dealing with condi-

tions where the natural mode of transmission was known, but in the case of both horse-sickness and blue tongue the manner in which the disease is transmitted in nature still remains to be definitely determined. We can, however, find an explanation in accepting the hypothesis which, amongst those acquainted with the problems that both of these diseases offer, is regarded as being so extremely feasible as to be very probably correct, though still lacking in direct experimental verification. This hypothesis is one which I am sure that most of you have heard of before, and is that both diseases are transmitted by winged insects of nocturnal habits, and most probably members of the group of Culicidæ or mosquitoes.

Now in accepting this theory as we do here it is not necessary to go into the evidence in support of it, although this would be extremely interesting in itself. Such a consideration would occupy much time, and it does not seem quite necessary to do so. For our purposes it is necessary to see whether, having accepted the theory, we can explain the influence of the climatic and tellurical factors on the distribution of the disease. This ultimately, then, really resolves itself into a consideration of how these factors influence the transmitting agent, which in this case is supposed to be one of the Culicidæ. Let us, then, enquire into the bionomics of this group in order to see what information we gain in this respect.

Now, if we follow Theobald on this point, we find that the mosquitoes are of wide-world distribution, the majority being vegetable feeding (the blood-sucking varieties being in the minority), and that in the life-cycle four stages are recognised, namely, egg, larva, pupa, and adult, or imago. That water or damp mud is absolutely essential to their development he shows in pointing out that it is only in places offering such that the larval and pupal stages can be passed, and that water influences the distribution of the adult form is seen from the fact that the adults occur in greatest abundance in damp marshy places, along river courses, and the borders of large lakes, and although they may be met with in some bare, rocky spots, yet even here water determines their prevalence, since they must for breeding purposes use the small collections of water such as are formed in the hollows of rocks or boulders. He points out also that heat importantly influences the rate of their development, acting more markedly on the pupal than on the larval stages, and he remarks that in warm climates mosquitoes may continue to breed all the year round in small numbers, although during the dry seasons they rest, and that in temperate and cold regions they pass the winter as either adults, larvæ, or ova. Altitude he refers to as offering no protection against their presence, and instances the fact that they swarm at a height of 13,000 feet in the Himalayas. Discussing the effects of weather on mosquitoes, he points out that they are very susceptible to weather changes, and that a certain rainfall is necessary for their development, this giving them the breeding facilities which are

not present under the conditions of a long period of dry weather, and it is important that moderate rains are more favourable to their increase than very heavy torrential rains, which latter may even be harmful through washing out small pools and vessels, thus destroying large numbers of larvæ and pupæ.

Finally, we may quote his remarks that although not all of the mosquitoes feed at night, and many Anopheles commence to bite before sunset, yet the majority of the Culicidæ are known to be of nocturnal feeding habits.

These facts, then, are sufficient to indicate that the climatic conditions which are favourable to the presence of horse-sickness and blue tongue are those which at the same time are favourable to the development of the mosquito, and that these latter insects are very prevalent in areas where the diseases occur has been a matter of observation. Even the remark made above as to the harmful effect of torrential rains on the development of the mosquito also has an importance to us, since it has been observed that following extremely heavy rains the prevalence of the diseases may be temporarily checked.

Thus we see, then, that through accepting these diseases as being mosquito-borne, we can explain the points noted previously in regard to their distribution and prevalence. The fact remains, however, that experimental verification of this theoretical explanation is still lacking, and that some insect other than the mosquito may eventually be proved to be the culprit in transmitting the disease. Even if such should eventually, however, prove to be the case, it will be seen that this will most probably prove to be an insect with habits very similar to that of the mosquito, as have been described above, and with the conditions influencing its distribution practically the same as those applying to the members of the Culicidæ group.

There seems little doubt that time and further experiments will furnish us with the direct proof that both horse-sickness and blue tongue are diseases which are insect-borne, and that is the reason that they have been included in this section of this present paper, and there would also seem to be little doubt that, in a similar way, we shall find that other of our South African diseases are transmitted in a like manner. In the case, for instance, of ephemeral fever, a disease due to a filterable virus, there is already strong presumptive evidence for believing it to be insect-borne in this country, and in the case of another disease due to a virus of the filterable group, namely, equine infectious anæmia, recently shown by Theiler and the writer to be present in South Africa, the evidence coming from Japan points most strongly to the disease being transmitted chiefly through insect agency, the particular flies on which suspicion rests in that country being included within the group of the Tabanidæ. It is therefore possible that in South Africa insects or Arachnidæ may be found capable of transmitting this disease, in addition to the mode of transmission, through the ingestion of the urine or material contaminated by the urine of affected

animals. Such a possibility, however, also remains a matter for further research to prove or disprove.

All of these facts, then, showing how favourable our subtropical climate is to the existence of tick and insect-borne diseases, it is satisfactory to be able to point to one example of a pest against which our climate seems to protect us, and this is to be found in the condition due to the presence in the subcutaneous tissues of cattle of the larvæ of the "warble fly."

In Europe and America the presence of the larvæ of the "warble fly" (*Hypoderma bovis* or *Hypoderma lineata*) in the subcutaneous tissue of affected cattle offers a very serious economic problem by reason of the damaged condition of the hides prepared from the skins of affected animals. In South Africa, however, the "warble fly" larvæ have not so far in any authenticated case been observed to be present in cattle born and bred in this country, nor, so far as the writer is aware, has the adult fly been met with, and the interest of this observation becomes apparent when we remember that the larvæ of the fly have been repeatedly introduced into this country in affected cattle imported from oversea countries.

This would seem to indicate that climatic and local conditions are in some way unsuited to the pupation of the insect in this country. The exact explanation still remains a matter for further work to supply, but it is possible that dryness may perhaps then be found to play an important part in this connection.

Here now, however, let us leave the consideration of these tick and insect-borne diseases, and pass to the next group of diseases to be dealt with.

Diseases due to Helminthic Parasites.

In considering this group two diseases may be taken to serve as examples illustrating the points which it is desired to make evident. One of these examples is a form of distomatosis due to a parasite of the group of flatworms or Platyhelminthes, whilst the other is a form of strongylosis caused by a parasitic worm of the Nematode group.

In considering these examples, we will first deal with the conditions due to the platyhelminthic parasite, and the particular form of distomatosis to which we shall refer is that caused by the presence of the parasite known for a long time as *Distomum hepaticum*, now more correctly referred to as *Fasciola hepatica*, and popularly known as the "liver fluke" or simply "fluke."

This parasite *Fasciola hepatica* is one which is met with in more than one animal species, but is perhaps best known as a parasite of the bile-ducts of the sheep, and the disease caused by it in this case has been recognised all over the world—as, for example, in Europe, North and South America, Australia, Japan, China, India, Africa, North as well as South, and in other places as well—as, for instance, the Sandwich Islands. It is thus a very interesting disease from the point of view of distribution,

and we shall see the importance of the factors which determine this distribution as we proceed to examine the manner in which the parasite is transmitted from one host to another.

Now in the case of this disease the importance of both sets of factors with which we are concerned is brought out, but the necessity of certain tellurical conditions for the development of the parasite is made very evident, for it happens that wherever the disease is met with, the conditions under which it exists always resemble each other in supplying water in the forms of pools, streams, etc., and thus it is a disease associated with pastures of a marshy, undrained, or generally wet character. This fact is, indeed, so striking that in many places where this disease occurs pastures of this nature are often referred to by farmers as being "flukey" of "fluke-struck." It is also, however, recognised that pastures of this nature favour the development of helminthic parasites generally, and hence, to see the especial importance which they have in relation to the development of the liver fluke, we must enter into some consideration of its life-history, which may be as briefly as possible put as follows:—

The adult fluke is met with as an inhabitant of the bile-ducts of affected animals, and in this position lays the eggs produced by it, which eggs, passing to the intestine, leave this in the fæces of the host animal, to be distributed on the pasture. The next thing that happens is that these ova so deposited now hatch under suitable conditions within a variable time, usually a few weeks, and from them emerges the next stage in the life-cycle, known as the ciliated embryo or miracidium. So far the life-history is, comparatively speaking, uneventful, but at this miracidium stage a crisis occurs in the life of the liver fluke, for if at this point a certain intermediate host animal is not met with, no further development can occur, and the embryo under these conditions may die in about 36 hours. Provided, however, that the suitable host, which happens to be a species of fresh-water snail, is present, then the further development proceeds. In this case the embryo bores its way into the body of the snail, and there passes to the next stage in its development, which is known as the redia stage; this redia stage may now in turn give rise to another generation of redia forms (daughter-redia), but eventually these redia forms give rise to the last stage occurring within the body of the snail, a tailed form which is known as cercaria. The next thing to happen is that these cercariæ leave the snail host, move about until they meet with the stem of some aquatic plant or with blades of herbage, up which they crawl, and, having lost their tail-like appendage, they there become encysted. It is now finally this encysted form present on the herbage which, being swallowed by a suitable animal—the sheep in this instance—develops within this animal to the mature adult stage, and in this form, and having reached the bile-ducts of its host, it there again lays its eggs to start the life-cycle afresh.

These facts, broadly stated, will thus show what an interesting life-history the parasite possesses, but for us they bring out

something more than this, and furnish us with the explanations for the peculiarities in regard to its distribution, for we have seen that without the intermediate snail host the complete development of the parasite cannot occur, and hence the distribution of this snail host must regulate the distribution of the parasite worm.

In this fact, then, we have the key to the importance of the tellurical conditions and the presence of water in regard to the distribution of the disease, and in knowing that the snail host is incapable of existing in the absence of water, although its habits are amphibious rather than aquatic. In Europe this snail host is *Limnæa truncatulus* or *minutus*, a fresh-water snail which is found in the neighbourhood of ponds, ditches, and streams. According to Theobald, it is to be met with in elevated as well as in low-lying places, occurring in the Pyrenees at a height of 4,000 feet, and he also remarks that the smallest natural collections of water can serve for its development. This snail, however, though of very wide distribution, is not a species met with in every country where the disease due to the parasite worm is encountered. In these instances, however, and where the intermediate snail host has been determined, this host has been found in a snail possessing habits in regard to water similar to those of *Limnæa truncatula.* Thus in the Sandwich Islands *Limnæa cahuensis* is mentioned as the intermediate snail host, whilst in North and South America *L. humilis* and *L. viator* respectively figure in this rôle.

In South Africa we find the same tellurical conditions influencing the distribution of the disease as we find elsewhere. It is a disease associated with marshy places or vleis, or along the edges of mountain streams and the pools formed by them, where these streams occur, and is especially prevalent in these places during very wet periods. Dixon states that it is especially prevalent in the Cape, Stellenbosch, Paarl, and Worcester districts of the Cape Province, and also that in very wet seasons it causes great trouble and losses to owners of sheep in the Cathcart and Stutterheim districts, and on the Stormberg and Sneeuwberg ranges. That it has been present in the Cape Province for a long time is shown by the fact that the Commission appointed to enquire into the diseases of cattle and sheep in that Colony in 1877, even then met with the established disease from the Wodehouse district, through the Stormberg range, to as far as the Molteno district. At that time also the association existing between the presence of water and the prevalence of the disease was recognised, and it is interesting to note that the Commissioners state in their recommendations that, in order to prevent the occurrence of the disease, the sheep in the places where it occurred would have to be kept away from marshy or boggy places or neighbourhood of streams or pools of water.

So far we do not know the details of the development of the parasite or the nature of the intermediate host in this country.

There is practically no doubt, however, that the development is along similar lines to that described above, and the occurrence of the disease is indicative of the habits which the intermediate host must be expected to possess. Gilchrist would appear to be the only worker who has entered into this question to any depth, and it is very interesting to note that his work indicates the intermediate snail host as being most probably existent in the snail *Physa tropica*. In this species he claims to have found the redia and cercaria stages of the fluke, but the non-detection of the encysted stage and the consequent absence of infection experiments unfortunately leave the matter awaiting final settlement.

Here, then, having seen from this example how the climatic and tellurical conditions may influence the distribution of a parasitic disease in what we may speak of as a rather indirect manner, let us now, in considering the other disease we have selected, study the more direct influences of these conditions on helminthic development. The particular example which we have here chosen is the disease recognised as occurring in sheep consequent upon the presence in this animal of a parasitic nematode worm, formerly known as *Strongylus contortus*, but now designated *Hæmonchus contortus*.

This worm, though met with in other ruminants, is most commonly a parasite of the abomasus of the sheep, and from this facts it has in many places earned the popular name of the "sheep-stomach worm." In this country, however, the common name applied to it is that of " wireworm " or " haarworm," and under these synonyms is known to sheep-farmers throughout the whole Union as causing a disease in sheep, and especially young sheep, which, under certain conditions, may be very serious. In some places where the pastures are of a wet or damp character, it is more or less always prevalent, whilst in other places its prevalence is usually most marked during the annual wet season. During very wet seasons, however, it becomes more generally and markedly prevalent than usual, and may then cause serious losses, especially in younger animals, unless preventive or curative measures are adopted.

The importance of the disease in this country, therefore, lends a review of the observations on the development of the parasite, an interest additional to that which it has for us in our broader considerations. In order to review these observations, however, we must, as we have already done in the case of liver fluke, first consider the life-history of the worm, and this is briefly the following:—

Commencing with the adult sexually mature parasites, we find these occurring in the abomasus or stomach of the sheep, and in this position they may be encountered in a large proportion of animals examined. The numbers, however, in which the parasites are found vary in different individuals and with certain conditions into which we shall not enter here. All animals carrying the parasite, however, do not necessarily show symptoms of

its presence, except on microscopic examination of the fæces, when the eggs of the worm may be found, and a very large number of adult sheep may be found to harbour at least a few individual worms. These, as mentioned before, may not produce any symptoms of their presence, but the importance of the animal carrying them in acting as a constant source of infection to the pastures over which it grazes will be apparent.

Continuing, however, with the life-cycle of the parasite, we note that, following the general rule, this does not occur within the body of the host, but can only occur outside it. The eggs must, therefore, reach the exterior, and this they do in the fæces of the host animal. Having done so, the next thing to occur is that they hatch, and form them emerges a form which is known as the larva; this larva now proceeds to feed, and having grown and cast its outer skin on two occasions, we finally meet with it in an ensheathed form in which the sheath possessed by it is formed from the retained cuticle cast at the last moulting. Now it is this stage which represents the infective form of the parasite, the eggs and earlier larvæ stages being incapable of producing infection, and for development to maturity to occur this form must again find its way into the host animal. This is accomplished, however, by the larva through climbing up the blades of grass and herbage in its vicinity, with which herbage it is consumed by its host, or perhaps in rarer cases though being consumed with drinking water, and now having gained the stomach of the sheep, it loses its sheath, undergoes further development, and within about three weeks' time is to be met with in the stomach as the adult sexually mature worm.

In coming now to consider the more detailed observations made in connection with the rate of this development we shall, therefore, speak of the different stages occurring outside the body of the animal as the egg or ovum stage, the immature larval stage, and the mature larval stage, and in dealing with the subject reference may first be made to the work of Ransom on the subject performed in America, the work of Veglia in this country being mentioned later.

The life-history of the parasite, as described by both of these workers, is essentially the same, but in regard to the biology of the worm some differences are to be observed in the results obtained. These differences, however, will not be discussed here, but the main facts observed by both workers are here set forth as evidence of the marked effect of heat and moisture on the rate of development of the worm, and some of Ransom's observations are as follows:—

According to this observer, the eggs do not hatch if the temperature is below 40° F., but under such conditions he says the eggs remain in a dormant state. Provided they are not destroyed by freezing or drying, to both of which they are very susceptible, he states, they may survive in this dormant state for two to three months and hatch, if a favourable opportunity occurrs.

Above 40° F., however, hatching does occur, and from 40°

F. to 50° F. this time may vary from a couple of weeks to a few hours.

The effect of temperature is further noted in examining the rate of development from the egg to the infective larval stage. According to Ransom, the rate of their development at different temperatures is as follows:—At a constant temperature of 95° F. this period occupied three to four days; at 70° F., six to 14 days were occupied; whilst from 46° F. to 57° F. the time occupied may be from three to four weeks.

The importance of moisture Ransom refers to in dealing with the final infective larval stage, for here he points out that "it is only when moisture is supplied that these larvæ can crawl up the blades of grass from which they gain access to their host." Even here, however, he states temperature is again an important factor, since below 40° F. he found the larvæ to show little or no activity. Provided, however, that the temperature is suitable, these larvæ, he says, crawl up the grass blades during wet weather and dewy nights, ceasing their migrations when the humidity of the atmosphere falls below saturation point or when the dew evaporates. Their movements, he further says, resume or cease according to the presence or absence of moisture, and thus they mount higher and higher up the grass glades, proportionately increasing their chances of being consumed by a host.

The importance, however, of actual collections of water such as pools he regards as being indirect rather than direct, in pointing out that the larvæ tend to fall to the bottom of these, and will only be ingested if sheep in drinking stir up the mud from the bottom of such pools. He believes that the chief importance such pools possess is in keeping the earth surrounding them moist, and at the same time raising the humidity of the air in their neighbourhood.

Observations made in regard to the effects of the reverse conditions of coldness and dryness are as follows:—Drying, he states, speedily kills the eggs and immature embryos, and a 24-hours' freezing may prove fatal in a number of cases. On the other hand, the sheathed infective larval stage is, according to Ransom, very resistant to drying and freezing. Thus he mentions that this form resisted drying for 35 days in fæces, and that, placed out of doors for a continuous period of 85 days, they were still alive at the end of this time, although for 494 hours of this period the temperature was 30° F. lower, the larvæ being thawed out 32 times and remaining continually frozen for over 48 hours on three different occasions.

Coming next to the observations made by Veglia in South Africa,* we may note some of his results in the same way, and the more important to us are the following:—

* These results, obtained by Dr. Veglia, have not as yet been published, but will shortly appear in the Report of the Director of Veterinary Research. The remarks made here refer to information verbally communicated to the writer for the purposes of this article through the kindness of Dr. Veglia.

The shortest time observed by Veglia as occurring between the egg and the final infective stage larvæ was three days, and this was noted at a temperature of from 22° C. to 35° C. The effect of decreasing temperature in retarding the rate of development is again seen in the fact that the same developmental period as that just referred to occupied six days at 15° to 18° C.; eight days at 15° C.; and 12 days at 15° to 13° C. In making field experiments, he noted in one of these, made in March, 1915, that the final stage infective larvæ were to be met with after four days, the maximum temperature recorded during this time being 26° C., whilst the minimum was 15° C.; in another field experiment, where these limits were 26° C. and 12° C. respectively, it was only on the seventh day that the larvæ were found crawling up the grass blades; whilst in a third and similar experiment, but with temperature limits of 26° C. and 8° C., only 10 per cent. of the larvæ were found on the tenth day to have reached the final and infective stage.

In regard to the effects of drying and freezing, he has noted that eggs resisted freezing up to 36 hours, and some for even 48 hours, and that, kept at 4° C., they died in from 40 to 50 days. The immature larvæ in some cases appear to resist freezing for 24 hours, but at temperature descending from 10° C., increasing numbers of them die when exposed for a similar length of time. He also noted that this larval stage in one experiment was not able, when present in fæces, to resist drying for more than ten days.

The resistance of the infective larval stage is evidence by the fact that after an exposure to a temperature of 0° C. from the 30th July, 1914, to the 21st December, 1914, 30 per cent of this stage larvæ were still found to survive. In regard to the effect of drying on this stage, Veglia remarks that when spread out in thin layers on either glass plates or dry grass blades, and not allowed to collect in the form of clusters (in which formation original moisture is retained longer than when the individual larvæ are well separated), they are invariably found dead in four day's time. In fæces, however, kept in the field, and thus deriving a certain amount of moisture from the soil, he has found 50 per cent. of this stage larvæ surviving from the 2nd April, 1915, to the 22nd June, 1915, but in another similar experiment, however, he found the same stage larvæ placed in a similar position on the 8th September, 1914, to have died out in June, 1915.

Another observation to which reference is made here because of its general biological interest and importance is the extremely interesting observation in regard to the effect of light on this larval stage.

The writer may point out that the effect of light in determining movements and activity of certain animals is an effect which has been before recognised, and especially in regard to larval forms. This subject is one which has been studied under the name of heliotropism, and according to whether light exerts

an attractive or repulsive influence on the particular form of life studied, two forms of heliotropism, a positive and a negative form respectively, have come to be recognised. A very interesting discussion of the purposefulness of heliotropism may be found by those interested in the subject, in Jacques Loeb's essays, collected under the title of "A Mechanistic Conception of Life," and many references to its possession by different living forms are there met with. So far as is known, however, it has not been before noted in regard to the larvæ of *H. contortus.*

Veglia found that in the case of these larvæ the phenomenon of negative heliotropism was exhibited and first noted this when watching the development of the larvæ in cultures kept in glass jars. In keeping them under such conditions and exposing them to lights of different intensities, he has noted that whilst in the presence of diffuse light or darkness they tend to crawl up the sides of the vessel in which they are kept (temperature and moisture conditions of course being suitable), and to heights increasing in a certain proportion as the light supply is lessened, they, on the other hand, are caused to quickly move down the sides of the containing vessel, into the layer of fæces at the bottom, when this glass vessel is exposed to a bright light such as sunlight. He has further observed that alternate upward and downward movements of the larvæ can be induced by alternating exposure to subdued light or darkness, and bright light respectively but after repeated excursions of the larvæ induced in this manner, they appear to become exhausted, for some time at any rate, and they retire into the layer of fæces, or earth containing fæces, placed at the bottom of the jar, and placing the vessels in darkness no longer stimulates them to move up the walls as before. The duration of this phase or its ultimate termination have not yet been fully determined.

The actual destructive effect of sunlight on the larvæ is also included in Veglia's observations, and he attaches considerable importance to it. Detailed reference, however, to all of these points will appear later in his publication on the subject.

This effect of light on the migrations of the larvæ will thus be seen to be of extreme interest, but the part which it plays in the biology of the worm under natural conditions, and how far it acts as a factor in regulating, along with temperature and moisture, the migrations of the larvæ up the grass blades during the night or in cloudy weather, and how far the harmful effect of direct sunlight on the larvæ may come to be exerted under natural conditions, are all matters requiring further investigation.

We may leave this part of the subject here, however, and go back to our former remarks on the effect of heat and moisture on the rate of development of the worm.

Recalling these facts and bearing them in mind, it is hardly necessary to emphasise their importance any further, and the importance of the part played by wet or damp pastures and wet weather is made evident. The facts, however, which have been

thus dealt with in regard to the life-history and biology of *H. contortus* are, when broadly generalised, applicable in a general way to most other nematode parasites causing stock diseases, and we find that warmth and moisture play the same general rôle in the development of the parasites causing them, and hence in the prevalence of the diseases themselves.

This therefore explains the reason for the greater prevalence of parasitic diseases of this nature on damp, marshy or undrained pastures during wet weather, and especially in those parts of a country where the wet and warm season happen to coincide, as happens over the greater part of this country.

It is not without interest, also, to note the association of certain diseases during these wet summer months and their increased prevalence. Thus the marked prevalence of horse-sickness, blue tongue of sheep, parasitic diseases generally—but especially of infection of sheep by *H. contortus* ("wire-worm" infection)—and of ephemeral fever or three-days sickness of cattle during the early part of this year, and their similarly marked prevalence in the summer of 1907, and similarly under very wet climatic conditions (ephemeral fever then entering the country from further north), is an association which has been observed. Such an association is, however, one which is capable of explanation along the lines which have been laid down in this article, and it is hoped that the explanation has been sufficiently clear to allow of its appreciation.

Having now seen from all of our previous considerations how the climatic and tellurical factors may exert their influence on the distribution of diseases of bacterial or helminthic character, and on those borne by either ticks or insects, we near the conclusion of our consideration, for, although the subject of the diseases caused by toxic plants is a fascinating one, we have not yet obtained, so far as South Africa is concerned, sufficient data to illustrate the points with which it would be of interest to deal.

This point to which I refer is the effect of climate and soil in determining the actual toxicity of the plant itself, and it is regrettable that we have not more exact data concerning this subject in South Africa, as it is a matter of general scientific importance. There is little doubt, however that time and other suitable conditions will remedy this state of affairs, and that our knowledge of this subject will then become amplified.

Ostertag and Zuntz, in Germany, have pointed to the production of toxic substances in grasses grown under certain climatic and tellurical conditions, which grasses were not toxic when the conditions were altered, and, as I am sure you all know, an explanation of the causation of lamziekte has been given following similar lines by Theiler, and it is therefore of importance that we should know under what exact conditions we may expect such occurrences, and investigations into the matter will have the highest interest.

There are, however, a couple of observations which have a bearing on the point, and to which reference may be made.

One of these is the observation made in regard to the toxicity of the *Senecio* species, and in this case, whilst it was shown by Robertson and Chase that a form of liver cirrhosis could be produced by feeding animals with the plants obtained in the Cape Province, yet the same species of plants collected at a later date, and in Natal, did not produce a similar affection when fed to animals in experiments made by Webb. The other observation is one of the writer's made in connection with the toxicity of *Cotyledon orbiculata* when fed to fowls. In this case it was noted that whilst the plant collected near Pretoria was toxic, yet the same species collected in the Cape Province (and with only a couple of weeks' difference in time of collection) did not prove toxic. The specimens of each plant were submitted to Dr. Schönland, of Grahamstown, an authority on the South African Crassulaceæ, but he stated that he was unable to make even a variable difference on any grounds outside of this variation in toxicity.

This indicates, therefore, that there is still an interesting field of research open in this direction for the chemist and pharmacologist, and it is to be hoped that the gaps in our information on these and similar points may soon be filled up.

These remarks conclude our examination of the broad outlines of the subject with which we are concerned. The presentation of the subject is admittedly imperfect, and this must necessarily be so, but if the writer has succeeded in arousing a more general interest in the subject than had previously existed, he will feel satisfied in regarding his object as achieved.

Hydrocyanic Acid in Sorghum.—The *Journal of Agricultural Research** contains an account by J. J. Willaman and R. M. West on a series of experiments conducted by them in order to ascertain the effect of climatic factors on the proportion of hydrocyanic acid in sorghum. They found that unhealthy plants usually contained more hydrocyanic acid than healthy ones, that an inadequate water-supply is generally accompanied by high hydrocyanic acid content, and that there is a proportionately smaller amount of the cyanogenetic glucoside dhurrin in thick heavy stalks than in slender ones. The large amount of hydrocyanic acid which accompanies inadequacy of water is ascribed to need of glucoside stimulation when the water supply becomes low, while in the case of unhealthy plants it is thought that a larger quantity of glucoside may be produced for the purpose of stimulating hormones.

* (1916) **6** [7], 261-272.

RHODESIAN RUINS AND NATIVE TRADITION.

By Rev. Samuel S. Dornan, M.A., F.R.G.S., F.G.S.

(*Plates* 15-18.)

The ruins scattered over Rhodesia have given rise to a hot and somewhat acrimonious controversy regarding their origin, uses, and age. Archæologists and popular writers have solved the problem in two different ways. A halo of romance has been woven around these ruins, and they have been projected back to the age of King Solomon. On the other hand, they have been reduced to late Middle Age in date, and degraded to the level of a glorified Kafir kraal. Bent and Hall drew lively pictures of a lost civilisation which Maciver rudely dispelled. All these writers have dealt with the problem from the archæological side, but none of them attacked it from the side of native tradition. It would have been worth while to have devoted some time to this line of investigation, and to have endeavoured to discover if the natives now residing in the area covered by these ruins had any traditions regarding their origin and use. Dr. Maciver, in his "Medieval Rhodesia," does not raise the question at all, while Mr. R. N. Hall, in his "Prehistoric Rhodesia," closes the matter by stating that:—

> The Makaranga, who have occupied Mashonaland and Matabeleland and the immediate hinterland of Sofala for the best part of a thousand years, have no tradition or even legend of the erection of the Zimbabwe Temple and its associated ruins, except that they say that the temple was built by the devil, just as their ancestors, more than five hundred years ago, stated that the temple was erected by the devil.*

He quotes De Barros, an old Portuguese chronicler, in support of this statement, and also gives other proofs that the Makaranga know nothing whatever about the origin of the old ruins. I hope to show in the course of this paper that these assertions require very serious qualification. In other words, I shall endeavour to prove that the natives have some traditions regarding these buildings, whatever reliance may be placed upon them. With regard to Hall's statement, I should like to make the following observations. Everyone knows that, in dealing with natives, one must have a thorough mastery of the language, and their complete confidence, before one can obtain trustworthy information, and then only with the greatest patience, care, and caution. Statements have to be tested over and over again before they are accepted, and even then one never knows how much one may have been told that the natives saw one wanted to be told. After a fairly long experience in dealing with natives, I can most positively affirm that I know no class of people more susceptible to suggestion in the way of imparting

* Prehistoric Rhodesia," 149.

information, so that anything in the way of leading questions must be avoided. I think that the natives who now live in the neighbourhood of Zimbabwe, Thaba's ka Mambo Khami, and other ruins dealt with here, do not know most about them, nor are they most willing to tell what they know. Every native fears every other. This was what led Hall astray. There have been great movements of population in Rhodesia within comparatively recent times, and we must go farther afield for our information. Not only has there been a great immigration into this country from across the Zambesi within the last 300 or 500 years, but we have as well the various Zulu incursions within the last century. All this has led to a great shifting of tribes and clans. Hence it is that in comparatively unsuspected places, and amongst relatively small tribes, the most important evidence has come to light. With regard to the veracity of the old Portuguese writers, very different opinions have been held. Many of them are fairly trustworthy; others are full of unsifted and unveracious statements, which have to be accepted with great reserve. Mr. Hall apparently considered them all as of equal value, and used them without caution. I have read several of them, and do not attach more importance to their information than I do to Hakluyt's "Voyages," for example.

There are two theories of the origin of the Rhodesian ruins before the public. The first, identified with Bent, Peters, and more especially Hall, asserts that they are very ancient, prehistoric in the sense of the term as applied to South Africa, that they were built by Semites, or under Semitic influence, ranging in point of time from something like 2000 B.C. down to about 900 A.D. The natives are held to have been quite incapable of erecting such buildings, and that they neither now nor at any previous time did actually erect them. Further, they are stated to have attempted to copy the designs of the original architects in a very crude and ignorant manner. A formidable array of proofs, archæological, ethnological, botanical, and architectural, are brought forward in support of this theory, so that at first sight it appears quite irresistible. But the statements are so general in their character, that, when examined critically, they fail to convince. Taking a few examples of so-called proofs of antiquity, this is what we find. It is commonly held by Hall and others that Zimbabwe is the oldest and best of the buildings, and therefore the prototype and pattern of all the others. Yet Hall asserts that Khami and Dhlo-Dhlo contain all styles of building, from the very oldest Zimbabwe type down to the newest, and were erected about 900 A.D. The fact is, there is no difference between the style of architecture at Khami and that of Zimbabwe except size and better preservation. The valley ruins at Zimbabwe are in much the same state as Khami. The signs of later and decadent walls are similar in both instances, and

what in one case is regarded as a later and decadent wall at Zimbabwe is simply a fracture in the wall caused by a subsidence of the ground. It is also asserted that the Mahobohobo tree was introduced by the "ancients," and is therefore not a native of the country. Mr. C. H. Munro has shown that it is not confined to the gold belts or ruins areas, but is an indigenous tree. It is of the genus *Photinia,* is often called the wild loquat, and is of pretty common occurrence.* All this only shows how general and how unsifted much of the evidence really is. But apart from all this, the Semitic theory assumes two things that themselves require to be proved. First, that there was any Semitic occupation of this country before the thirteenth century A.D., or much between that date and the coming of the Portuguese at the beginning of the sixteenth. Second, that the natives are or were incapable of producing unaided such buildings.

A further proof is sometimes advanced that the natives of Zimbabwe and other districts have been largely influenced morphologically and culturally by the Semitic colonists. Of the first, no satisfactory proof has been forthcoming, beyond vague inferences which mean little or nothing. The second rests upon the fallacious assumption that because the natives could not build these ruins, or do not build similar ones now, *ergo* they did not build them. The third may be dismissed with the remark that general agreements in appearance and customs can be found amongst widely separated peoples, who have otherwise no near relationship at all. Lord Kingsborough attempted to show, for instance, by the resemblances in customs and architecture, that Mexico was colonized by the Israelites! But the fact is the Makaranga of the Zimbabwe and other districts have no special Semitic or even Hamitic characteristics, and their language has not been influenced to any appreciable degree, either in grammar or vocabulary, yet Mr. R. N. Hall states that the Bantu arrived south of the Zambesi River some time about 300 B.C. They would thus arrive in the middle of the Semitic colonization, and yet they show no trace of foreign influence.

The second theory is identified with Maciver, though others had suspicions before him, whose investigations were carried out on scientific principles. They led him to the conclusion that these ruins were medieval and post-medieval, that they were built by negroes, and that in the case of Zimbabwe itself not earlier than the fourteenth or fifteenth century. The evidence was convincing enough. Nothing but native work was found in or about the ruins with the exception of Persian fayence and Nankin China, the introduction of which was easily explained. When the buildings themselves were examined, the

* Professor H. H. W. Pearson informs me that little evidence can be adduced of Semitic influence from the distribution of vine or orange.

† Prescott: "History of the Conquest of Mexico."

testimony was the same. They were typically African negro, they were round or oval, the courses were irregular, and they had been built on no definite plan. There were no square corners, and the stones had not been dressed in the proper sense of the term. The natural fracture of the rock had played a large part, and the best face of the stone was placed outward. All this the writer can personally confirm, as from a careful examination of Zimbabwe and its associated ruins, I became convinced, if further conviction were needed, of the truth of Maciver's theory. What specially struck me was the newness of the buildings. They had no ancient look about them. There was no sign of weathering to suggest high antiquity—the faces of the stones were too fresh for that—so that they could not have been more than 500 years old, and probably much less. The following notes on the various ruins were made at the time:—"The walls are very new; there is no ancient look about them. The courses are irregular, and the outline is not uniform. They could not have been built with the aid of a batten gauge, as no two courses have exactly the same batten when carefully measured; thus there could have been no definite plan. The stones are only roughly dressed, the natural cleavage of the rock playing a considerable part. The best faces are outward, and the others not dressed at all, and hence the stones have quite a fresh appearance, and there is no sign of long weathering about them. The building of the wall really amounts to erecting two outer walls and filling in the space between with fragments, without any attempt to lay courses.

The "Temple" is not a temple at all; it was the residence of a chief. The duplication of the walls had nothing to do with worship, and was simply for the purpose of protection; the sunken passage from the valley ruins to the temple proves that. The supposed resemblance to the temple at Marib in Arabia is purely fanciful, and the herring-bone pattern at the top of the eastern wall to the inscription on the Marib temple is equally imaginary. The herring-bone itself is nothing remarkable, and occurs in all the ruins that I have seen, some better and more elaborate than that of Zimbabwe, as for instance, Khami and Nanatali, as may be seen in Maciver's book. The cones were built over the graves of chiefs, hence the great cone marks the grave of some great chief, and the idea still survives in piles of stones or low conical accumulations of stones over the graves of chiefs in other parts of South Africa. The other part of so-called temple was the residence of chief's wives, and possibly also some of his indunas. The monoliths of soapstone were not all originally on the walls; they have been placed there subsequently, but some were used as door-posts, as can be seen in the valley ruins. Soapstone pillars with crocodiles and hawk-like birds carved upon them, stood at the entrance to the kraal of the great chief or great doctor. They were the totems of the tribe, and hence the insignia of his office. The same thing can be seen at the

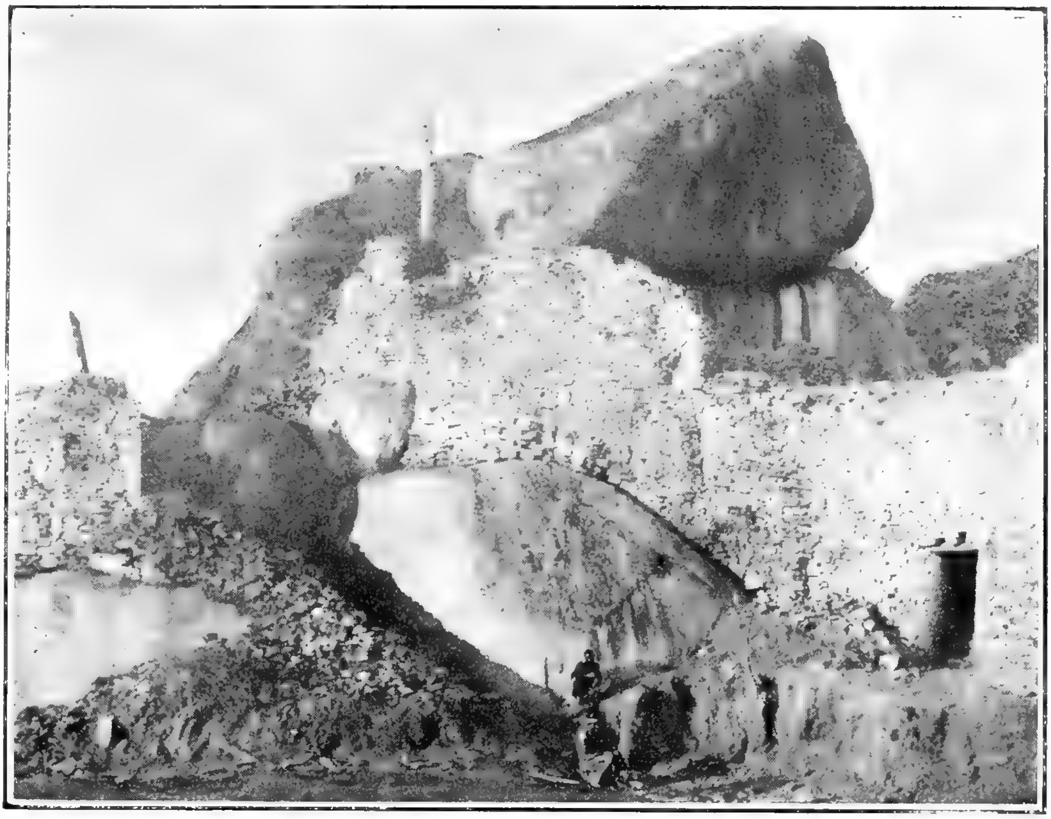
Acropolis ruins. Only the granite pillars appear to have been on the walls at the beginning.*

The valley ruins were the dwellings of the common people. This is evident from the construction. There is no sign of the later and decadent walls. The slipping of the foundations in two cases has been mistaken for such. The sunken passage was for communication with the fortified kraal of the chief in case of attack. It would be easy to assault the dwellings on the plain, and everything inside suggests native occupation, and at a fairly recent date.

The Acropolis occupied a position of strength in case of attack. There were sunken passages communicating with the hill. The traverses have round corners, and the rock passage was suggested by the natural cleft in the rock, while the west passage is similar to that between the temple and the valley ruins. There are probably other passages undiscovered. All the buildings, temple, and valley ruins, were originally enclosed by a low ring wall, of which only the portion below the Acropolis now remains. Large pits now full of water remain to show where the clay was dug from to fill up the floors on the Acropolis and other ruins. These are quite visible in the southern and western valleys. The floors were raised as the occupation lasted, and thus the walls had to be raised. This is evident on the Acropolis. The so-called cement is nothing more than native dagga, and is simply granite soil. Excavations were being carried on at the time of my visit. Two native axe-heads had been found 8 feet below the present surface of the ground. They are indisguishable from axes used to-day in the country, and on the Zambesi. Two native hut foundations were also uncovered. The marks of the floors with the smearing as to-day, and the corrugation of the poles of which they were built, still remain. The soil inside the walls and forming the platform upon which these huts rested was carried up on the heads of the occupiers, and is exactly similar to the granite soil at the bottom of the hill. This had been worked into a paste with cow-dung, and formed the cement of which the floors had been made. The successive smearings could be seen. This siliceous granite soil sets as hard as cement.

There was no stratification of the floors to be seen. They presented a uniform appearance as far as the excavations had gone, which indicated continuous occupation by natives, who threw out their rubbish and ashes and gradually raised the surface. One was also able to see where huts had been burnt down accidentally or otherwise, and then rebuilt, and also where fires had been lighted for domestic purposes. The excavations in some cases had reached the granite foundation, but the top of the hill is very irregular, being composed of granite boulders, some of enormous size.

* Monoliths or pillars are not confined to the Rhodesian ruins, but have been found at Ilife, in Nigeria, where the people speak of them as "Staves of the Gods." (Frobenius: "The Voice of Africa," **1**, 298.



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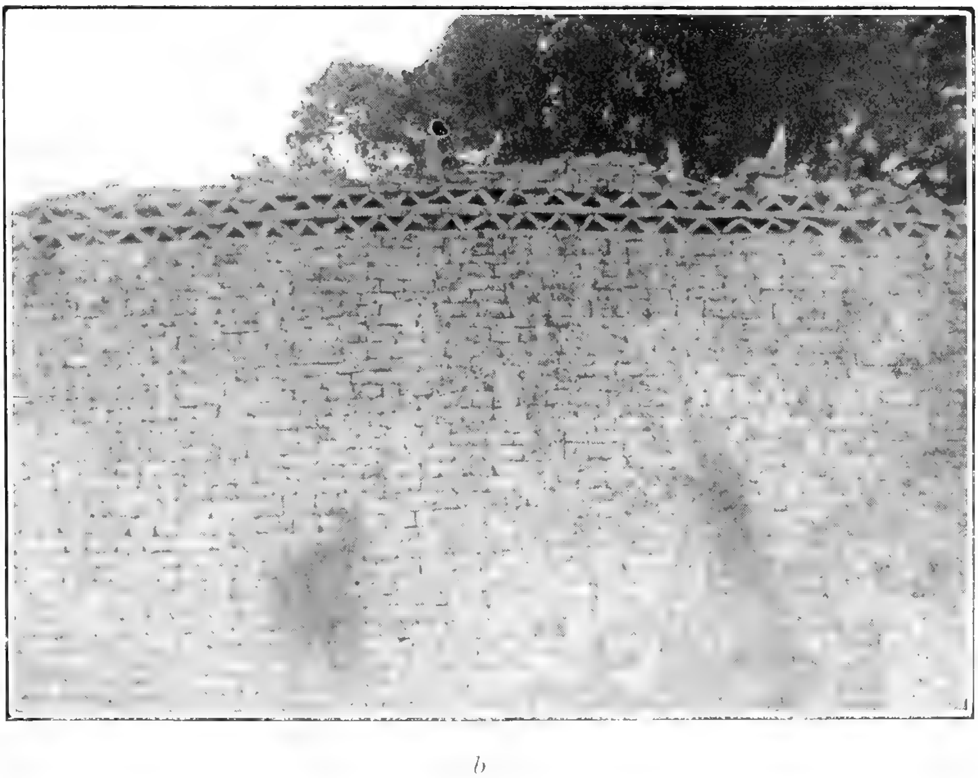

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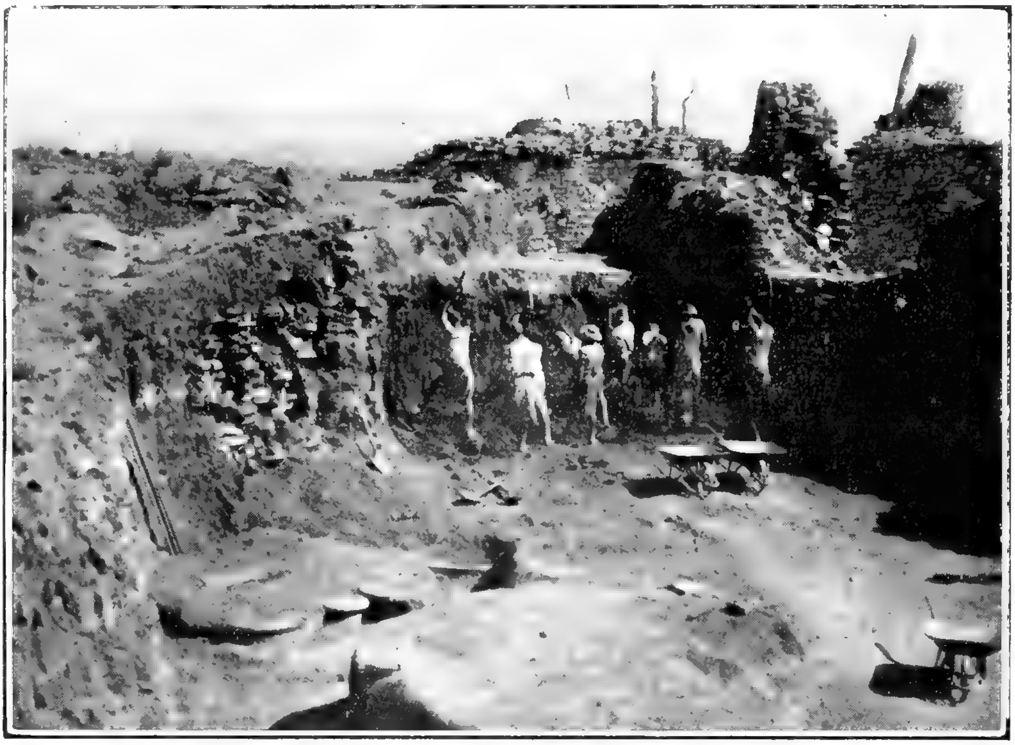
REV. S. S. DORNAN.—RHOD SIAN RUINS AND NATIVE TRADITION.



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Rev. S. S. Dornan—Rhodesian Ruins and Native Tradition.

The inhabitants of the district have no special Semitic or Hamitic characteristics that I could see. The gold industry was rather crude, and the amount extracted from the ground much exaggerated. Zimbabwe is not in the gold belt, and so if it had to be stored there was brought from a considerable distance. The same applies to Thaba's ka Mambo and Khami. Zimbabwe being the residence of the chief, would naturally be the depot for gold, tusks and ostrich feathers.

The foreign influence theory must be given up. Zimbabwe was built by natives, inhabited by natives, and recently abandoned, probably not more than 300 years ago. These walls are so badly built that they would have fallen in ruins if they had been 1,000 years old or anything approaching that, not to speak of being upwards of 3,000 years. They were built by natives, whose descendants may still live in the country, or who were recently "wiped out." Confirmation of these notes will be forthcoming in the following pages. As I am dealing mostly with native tradition, I shall now give three statements made to me at different times by intelligent natives regarding the origin and use of these buildings. They are typical of many others that I have heard, but I give them because they were made by men who were unknown to each other, and who came from widely separated localities, and belonged to different tribes. Every effort was made to test their truth at the time and subsequently. I shall also give some corroborative evidence from other sources bearing on the subject matter of the statements.

My first informant is named Chapa, and resides at Inyati, about 50 miles from Bulawayo. He was chamberlain to Lobengula, and came up from the Transvaal with Umzilikazi in 1839 or 1840. He was a small boy at the time, and thus, when he gave me the information in 1911, was an old man of upwards of 80 years. His faculties were quite unimpaired, and he was, moreover, intelligent and quite clear as to what he saw with his own eyes. He even drew a plan of Zimbabwe in the sand for me, to explain some of his statements. This was very close to the real thing, wonderfully so for a man who had not seen the place for over 40 years. Here is his statement:—

"When the Amaswazi arrived in Rhodesia (the first wave of Zulu immigration) the Mambo* was living in his castle at Thaba's ka Mambo. Thus we were not the first to destroy these fortifications. They were ruins before we arrived. (The Amaswazi destroyed them. The Amaswazi came here and remained about two years). They were here to eat one corn and to see another corn in the gardens. They came immediately before us, about two or three years. That is why we got such an easy conquest, because the Amaswazi had killed the Mambo's people. The Mambo went up our river (the Inkwesi), where he built another fort, which still exists, about eight miles from here (Inyati). They had not the trimmed stones up there; they had

* *Mambo* is the Karanga or Shuna word for chief.

to take the stones as they found them (as they had not time to trim them. The son of this Mambo, whom we killed, went over to Chibi to the Zimbabwe there. Inyaningwe is the name of the mountain near the ruins (Zimbabwe). Inhamohamo was the name of the chief. He was the son of this Mambo. He built it first.

"The same Mambo (of Thaba's ka Mambo) who built Dhlo-Dhlo, when the Amaswazi drove him out of Dhlo-Dhlo came over to Thaba's ka Mambo and built it. The stones were only for the fort; the houses inside were ordinary huts. They were hiding in the towers during the fighting. The river at Zimbabwe is a short distance from Zimbabwe. (Here my informant drew a plan, wonderfully accurate, to explain the position of the various ruins at Zimbabwe). He had taken his first wife (would be about 18 or 20 years of age). When he first went to the ruins, he found young trees growing in them. They (the Makaranga) built them, as we do now, with dagga. We built formerly with sticks thatched over with grass. When he was grown up these walls did not look new. I have lived with the old slaves who have actually seen with their own eyes the Abagamambo (people of the Mambo = Makaranga) build these walls. The white people from whom they (Abalozi) bought things first were Portuguese. For instance, the two old cannons were brought by the Abalozi (Abagamambo) from the Portuguese to resist us."

I may explain that Makaranga in Shiswina or Seshuna, as it is popularly called, becomes Makalanga in Sindebele, so that Abalozi, Makaranga, Abagamambo and Varoswe are practically synonymous terms for what we collectively call the Mashuna tribes. Makalanga becomes Makalaka in Sechuana, and so on. In the above statement I have not indicated the questions, but they can be easily gathered from the context, and the words in brackets are only added to complete the sense. They were written in at the time the conversation was taken down. It was much more detailed than the above summary indicates, and was repeated in many different ways to test accuracy. But the old man was quite clear and positive on one thing—that the Abalozi or Abagamambo (Makaranga) built these ruined towns, at a recent date, and that some of them were inhabited by the Makaranga at the time the Amaswazi and Matebele came into the country. This is strengthened by evidence from another source. It is stated that some of these defeated people fled to the Wankie district, where they found a refuge amongst some of their brethren who had migrated about 50 years before, and had built a similar town on the Bombusi Valley. I shall give the story of the migration when dealing with the statement of my third informant. With regard to what Chapa says about Zimbabwe, I do not place too much reliance upon it, as he apparently had not been struck with any difference between it and the other castles, as he called the ruins, and I am of opinion that Zimbabwe had been abandoned then. But it may only have

been abandoned by its occupants after the incursion of the Abotshangana (Shangans). This seems to be borne out by a reference to Wilmot's "Monomotapa." Father Nicolao of Tete writes (1586):—

> The Zimbas or Muzimbas are new people who from their native kraals have entered Ethiopia, killing everything, eating human flesh. They are to this country what the Goths, Huns, and Vandals were to Europe. They advanced quickly through many lands, and as they met with no resistance desolated all. The natives hide their provisions, and join these barbarians to escape death and their teeth. They ran through three hundred leagues on the shores, entered Monomotapa, entrenched themselves, and went out on excursions. The Portuguese fortified themselves on the Zambesi, at places distant sixty leagues from the other, one of these places being Sena and another Tete, both under the orders of the Captain-General of Sofala. These places serve as factories to collect gold.*

It is strange that Wilmot did not see the implication of this quotation himself. Here lies the true explanation of the abandonment of these fortified towns by the irruptions of marauding hordes like the Mantatees and Tembus of more recent times. This must have occurred often in the history of Monomotapa, and I am inclined to think that the actual abandonment of Zimbabwe was considerably later than the date of the above passage, possibly as late as the attack of the Shangans. This was Maciver's explanation, and I have little doubt that it is the correct one. The destruction of Varoswe (Abalozi) civilization was not at all accomplished by one tribe, or at one time. It probably extended over several centuries, and may well have begun before Father Nicolao wrote, and ended by the arrival of the Matabele in 1840 or thereabouts. It may be assumed that after each successive attack of barbarians rebuilding and reconstruction would be hurried, and hence would cause a decline in workmanship. It is said that down to the time of Augustus, Rome still showed signs of the haste with which it had been rebuilt after being burnt by the Gauls. This would readily account for the differences of style and execution observed in the various ruins, and is borne out by what Chapa says of Thaba's ka Mambo.

I now pass on to my second informant, a Shangan named Bote from Mount Silinda in Mashonaland, one of Zwengendaba's people, who came from Natal about 1836, and attacked the Makaranga in Rhodesia. He is an intelligent native, and has been employed for some time as a teacher. He says that he merely repeats what he has heard the old people, both Makaranga and Matabele, says many times. This is his story:

> The Makaranga say that they paid men (Arabs) to build these places for them to worship their Amadhlozi (ancestral spirits) in; that they were built a long time ago, so long that they cannot name the chief under whom they were built. They also say that one of the men who helped to build some of the palaces like Zimbabwe came back long afterwards, in the early days of Lobengula, to look for the mines where they used to

* Wilmot: "Monomotapa," 213.

dig the gold, and Lobengula refused. He went back, and Lobengula sent an impi after him and had him killed, because he was spying out the mines. Jena and old Makaranga told me this at my home (Mount Silinda). He died last year (1913). These Arabs wrought the mines, and used to light fires, and then when the rock got heated picked it out with picks, and then they made a fire and the metal ran out. The Makaranga were working with the Arabs, and when the Portuguese came the Makaranga worked the mines for them. The chief of Monomotapa (Mambo) paid the Portuguese elephants' teeth for their trade goods, cloth, and so on. The Makaranga called the Arabs *Mugang' antare*, which means the "iron wearers," because their clothes looked like iron, and the Portuguese were called *Klanzani*, because, like the fish, they came from the sea. The Arabs were not long away before the Portuguese came. Just after the Portuguese were away, the Amaswazi came, and since they came there have been three kings of the latter, Nyamande, Umzila, and Gungunyama. The Arabs came from the north, and married the Makaranga women, and when they went away, left their families and servants Mazungu (white people) to this day.

This statement contains several most important items of information. We are told that the Arabs got the natives to dig the gold for them, and that the Portuguese did the same; that the natives got the Arabs to build the walls for them to worship their Amadhlozi or ancestral spirits in. Regarding the statement that the natives dug the gold under the supervision of, and for the Arabs, and subsequently for the Portuguese, we have the statements of the old Portuguese writers themselves in confirmation thereof, quoted by Wilmot.

The Emperor prayed the Portuguese to take possession of the gold and silver mines. The expedition could not proceed to seize these sources of wealth. Father Monclaios (1572) says pointedly, "Others have written descriptions of the great quantities of gold and silver in the mines, but in the main all that we know is much less than is announced in Portugal. They are digged out when people intend to buy stuffs for clothing; the King of Monomotapa had given such mines to some Portuguese who had gone to his court, but they soon abandoned them, as the trade in stuffs and Indian mantles was far more important and profitable." Father Manuel Barreto says (about 1550), "All Mokaranga is a perpetual mine of gold." He says that the gold from the rivers was preferred to that from the mines. Pits were made and at certain times a ladder was let down, and the Kaffirs extracted quartz gold. When an irruption of water took place the work was suspended.*

Yet in spite of all this Hall, in his "Prehistoric Rhodesia," quotes† a formidable array of Portuguese writers in support of his statement, that in the time of the Portuguese the natives knew nothing whatever about digging gold from the mines, and only knew of washing the gold-dust from the river sands. It is certainly strange that he should have overlooked these and other similar passages, if he had read his authorities with care, but the fact is Hall was too prone to accept statements without verification, and was thus led into grave errors. In fact, many of his references have been borrowed from other writers. That the natives did actually extract gold from the rock until comparatively recent times is a fact according to Mr. F. C. Selous

* Wilmot: "Monomotapa," 209.
† Hall: "Prehistoric Rhodesia," 32.

and others. It is not so very long ago since they did so in the Mazoe Valley, as an official of the British South Africa Company informed me. Mr. Selous thus writes

> The gold mining went on without interruption till early in the present century, and the old men among the Matabili who took part in the first raids made amongst the Mashunas by Umzilikazi's warriors state positively that they found the Amaholi (Makaranga) working for gold in the *Amaguti*,* *i.e.*, the deep holes btween the Zweswi and the Umfuli rivers. An interesting confirmation of this statement lies in the fact that at the bottom of an old shaft, 120 feet deep at Concession Hill, Mr. Cock in 1891 found a bucket and a rope made of machabel bark, besides some iron implements. Now this bucket and rope evidently intended to haul quartz up from the bottom of the shaft, being made of such perishable materials as bark, could not possibly have been of any very great antiquity, whilst the iron axes, etc., were absolutely the same as those in present use amongst the Mashunas and showed no signs of age. Mr. Rolken, the American mining expert lately in Mashunaland, also told me that, from the condition of the heaps of debris at the mouths of some of the shafts, he was convinced they had not been long abandoned.†

Mr. Selous also gives a quotation from Baines, "The Gold Regions of South-East Africa," containing the statement of an eye-witness, Mr. George Wood, as to how the natives extracted the gold, which the latter repeated to Selous, so that the fact is beyond question. The quotation reads as follows:—

> G. Wood took me to a place in which he had seen a heap of quartz burned and another heap piled with wood amongst it ready for burning. The crushing stones, like a painter's slab and muller, had also been lying in a hut near, but at the time of my visit these were removed and the calcined quartz; but the other heap had been fired and now lay mingled with the charcoal ready for crushing.

Mr. Selous also states that he was at Tati himself, and personally inspected an old shaft with a heap of roasted quartz beside it ready for crushing, and several round stones to be used for grinding the quartz. The roof was supported with *mopani* logs cut with native axes, and covered with the original bark, so that he concluded that the shaft was abandoned about 1840, when the Matebele came into the country, and this was on their route. Yet in spite of all this, and much more information of a like character personally known to the writer, we are gravely informed that the natives knew nothing about gold mining. As a large part of the Semitic theory of the origin of Zimbabwe and its associated ruins rests upon the ignorance of the natives of rock mining and the excessive antiquity of the mines, the bottom is absolutely knocked out of it by these and similar facts. Mr. Selous was in Rhodesia long before any Europeans settled in the country, and he had ample opportunities of obtaining first hand information. Few men, if any, have had more.

Next let us take the statement that the Mambos got the Arabs to build these towns and "temples" for them to worship their Amadhlozi in. There may be a certain foundation for it in

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* Correct form *amagodi* or *imigodi*.

† Selous: "Travel and Adventure in South-East Africa," 336.

this way, that the Arabs may have acted as clerks of works, while the chiefs supplied the labour. From what we know of the power of native chiefs in recent times, it is quite certain that they could have commanded the services of thousands of labourers; forced labour, of course. The thing is possible, and may have been done in this way, and if so, it would afford an explanation of the supposed Semitic characteristics of the walls, and would bear out the assertion of late medieval date. As to the object for which the buildings were erected, to "worship their Amadhlozi in," that is quite in keeping with Dr. Maciver's suggestion that part of Zimbabwe was used as a temple by a witch doctor or priest king, and this is borne out by the religious customs of the Makaranga, where

The chief acts in the capacity of high priest. The persons possessing second sight or prophetic inspiration (*mondoro*) assist him in the performance of the rites. The *mondoro*, by reason of being inspired by the shades of the departed, can give the nature of the sacrifice which will propitiate the offended spirits.*

That the Mashuna have considerable ritual competent observers are now agreed. Dr. Wilder, in his paper on "Ndau Religion" in the *Hartford Seminary Record* for 1907, shows clearly that the Ndau people, who are a branch of the Makaranga, have a large and fairly elaborate ceremonial, just such as would be required by a building like Zimbabwe. Not all Zimbabwe was used for this exclusive purpose, but as the chief is the priest and rain-maker, the two offices were discharged by the same person in the same place. This is certainly a remarkable confirmation of Maciver's shrewd guess at the object for which Zimbabwe was built. My informant also told me that there was a smaller Zimbabwe on the Sabi River, in Portuguese territory, and that a king lived there till the Amaswazi came, and that they killed him and drove the people out, and that they never went back; that this king was also the head doctor of that tribe. He gave me his name, but I neglected to write it down at the time.

I now come to my third witness, Chiminya, a Batonga from the neighbourhood of the Victoria Falls. He is neither Matebele nor Mashuna, and so his testimony is all the more valuable on that account. He is an intelligent man, and has resided in Bulawayo for many years, and I have found him careful in all his statements. I have repeatedly raised this question with him, and he always gave the same version each time. It runs as follows:

I have heard from the old Makaranga and Matebele that the Mambo lived at Thaba's ka Mambo, built Thaba's ka Mambo and Khami. I have heard them say so many times. He did not use these places to live in, but he used them to fight in, when anybody came to fight him like the Amaswazi (*i.e.*, he used to retire to these places for defence). I have heard it said that the Mambo of Thaba's ka Mambo ruled as far

* Posselt: "Social Condition of the Natives of Mashonaland,"—*Proc. Rhodesia Scientific Association*, **12**, 131.

as Chibi (Zimbabwe) and that those towns were built by his orders. I have never heard it said that he employed Arabs (Mazungu) to build them, but I have often heard that there were plenty of Arabs in the country at the time, and that the Portuguese drove them away. But not all of them, as some of them were married to native women. They came for gold and elephants' teeth. There were many of them, and they built themselves houses.

Here, again, we have definite information connecting the ruins with the natives, whose descendants live in the country at the present time, and that they were built by those people. I do not attach great weight to the statement that the Mambo of Thaba's ka Mambo built Zimbabwe, although my first witness Chapa said the same thing. I think a Mambo was meant, one who lived a long time ago, but the way the statement is made shews that there is an intimate connection between Zimbabwe and the other ruins, such as Khami, Dhlo-Dhlo, and Thaba's ka Mambo. Further investigations may yet prove that Zimbabwe is younger than these ruins, and is, so to speak, the finished article. These Mambos were powerful chiefs, and had a certain degree of civilization. They were not warlike, and made but a poor fight against the fierce Matebele and Amaswazi, who swept everything before them from Natal to the Zambesi, and far beyond. So many displacements and so much destruction of population have taken place in South-East Africa that the history is now very confused and hazy, and with the passing of the old men will be lost altogether.

Regarding the building of Khami, the assertion of Chiminya receives confirmation from quite an unexpected source. Mr. H. N. Hemans, formerly Native Commissioner at Wankie, investigated the history of the Abenanzwa tribe, who are an offshoot of the Mambo's people of Thaba's ka Mambo, and who migrated to their present location about a century ago under a chief called Siawanka. The account was derived entirely from native sources, and may be taken as correct, the greatest care being taken to check the information obtained. Mr. Hemans thus writes:

Siawanka, at the Bombusi (River) built a large town, the principal houses being built of dressed stone, with roofs of poles and grass. A couple of feet from the tops of the walls themselves the stones were arranged in herring-bone pattern, or else diagonally, as an ornamentation, which would appear to be very similar to the effects of the walls at present standing at Zimbabwe. (The Abenanzwa attach no meaning to this variation in the laying of the courses). Spaces were left for the doors, which were made of dressed timber filled in with reeds. Round and about these houses of stone were built ordinary pole and dagga huts for the tribe as a whole, the more imposing and substantial houses being reserved for the king and his family and the chiefs. Remains of this town are still to be found at Bombusi, and have been thought, but erroneously, to have been built at the same time as the buildings which remain on the Khami and Lundi Rivers.*

Now all that is said here of the ruins at Bombusi is true of those at Zimbabwe and other places, so that when we read

* H. N. Hemans: "History of the Abenanzwa Tribe."—*Proc. Rhodesia Scientific Association,* **12**, 87.

that Khami contains all kinds of architecture from the best prehistoric Zimbabwe period down to the most recent Kafir hut, while Bombusi of the same kind is thus far younger, one wonders on what evidence the various styles of architecture are separated and assigned to distinct dates, and on what grounds such separation is upheld. Apart altogether from native tradition, we have the testimony of the buildings themselves. Messrs. Garbutt and Johnson, in an article in *Man* for July, 1912, gave cogent reasons for regarding a five-chambered hut at Khami, of which they give a plan, as contemporary with the walls themselves, as it was built on the same principle and in the same way. Many such huts inside various ruins in the country were recklessly destroyed because they were considered to be long subsequent to the walls, as of native origin, and therefore worthless as archæological data. Treasure hunters and R. N. Hall himself admit having destroyed some, thus their evidence is not now available for settling the dates of the various ruins.

I again quote Mr. Hemans:

> Siawanka built his town at the Bombusi in imitation of Zimbabwe, which, although they have never seen it, the Abenanzwa describe as of great size. They say that their ancestors built Zimbabwe (which is a name only, with no meaning, saying it was the place of the Mambo). Prior to their trek into Matabeleland, which they made by way of Selukwe, they had already lost the name of Zimbabwe, and had been in the habit of speaking of the place as "*Maduna a ka Mambo*" or "*Ntaba zi ka Mambo*," by which name they called their new settlement at Inyati.*

That the natives have not lost the art of building in dressed stone several competent observers have assured us. I shall quote only one, namely Mr. F. C. Selous:

> Whilst speaking of these carefully fitted stone foundations on which to build huts, I may mention that in the centre of Umtasa's deserted town on the Chodzani River—a town which he built himself, and from which he was driven a few years ago by the Abagaza—will be found a similar hut foundation, very carefully built of small slabs of granite beautifully fitted without mortar or cement, which proves that the art of building walls of carefully-fitted granite stones is not even yet dead among the Mashunas. . . . About half a mile from this old walled town was the burial place of Chipadzi, one side of which was enclosed by a beautifully-built wall about 10 feet high, of evenly-laid and squared granite stones, most carefully fitted together without mortar or cement of any kind. This wall was an exact facsimile of the best-built portions of the great Zimbabwe, and no one who has examined both these relics of a bygone age can doubt for an instant that they were both built by the same race of people.†

Mr. Selous further says that the builders of Zimbabwe were very rude people, possessing no instruments of precision for laying down accurate lines, and this is exactly the same impression that has been made upon others. It is rare that one finds a wall for any considerable distance quite straight. I have examined most carefully the buildings at Zimbabwe, Khami, and Selukwe, near where Mr. Selous found the old shaft

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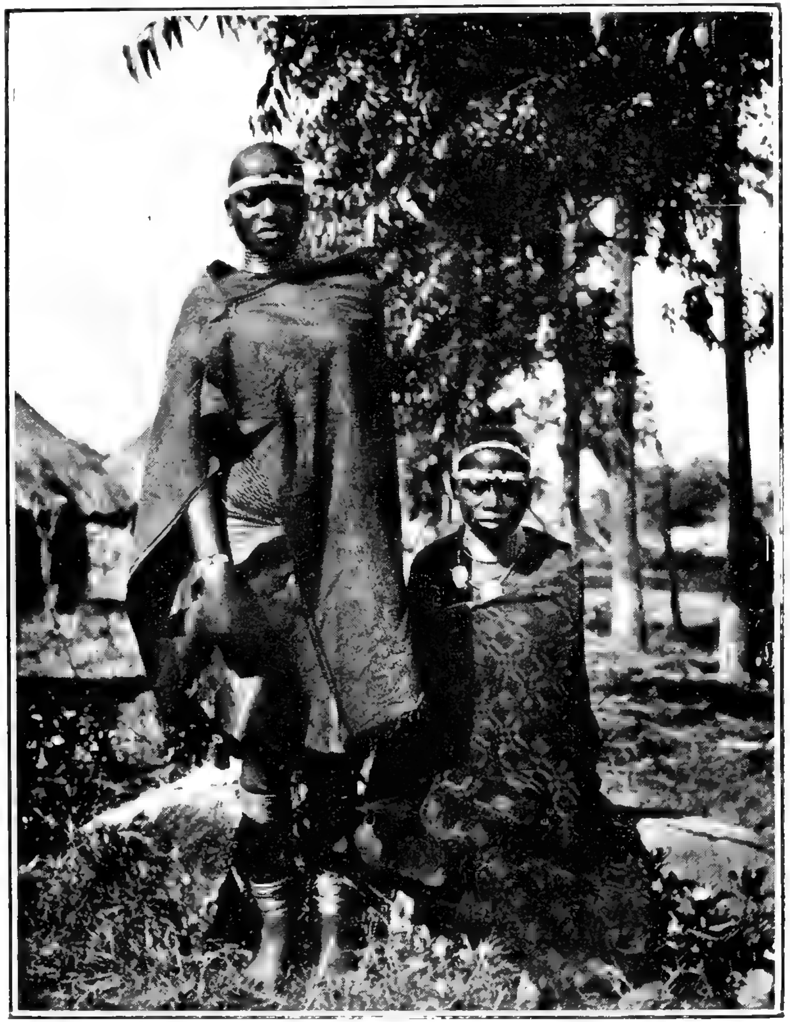
* H. N. Hemans: "History of the Abenanzwa Tribe."—*Proc. Rhodesia Scientific Association*, **12**, 91.

† Selous: "Travels and Adventure in South-East Africa," 340.



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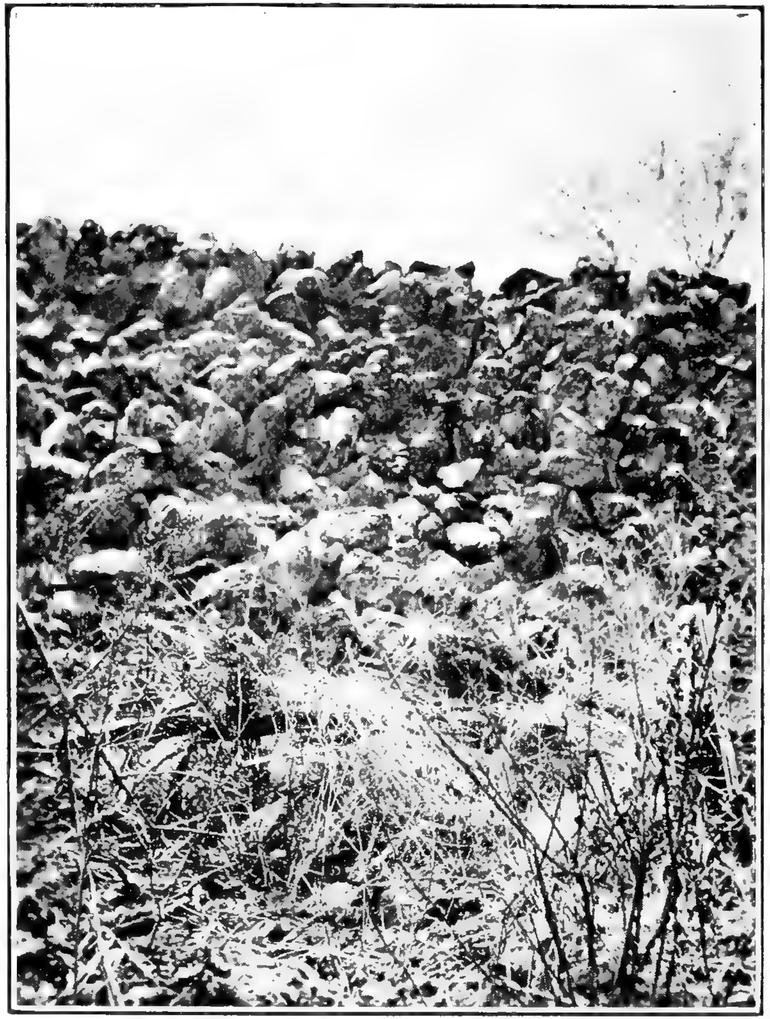

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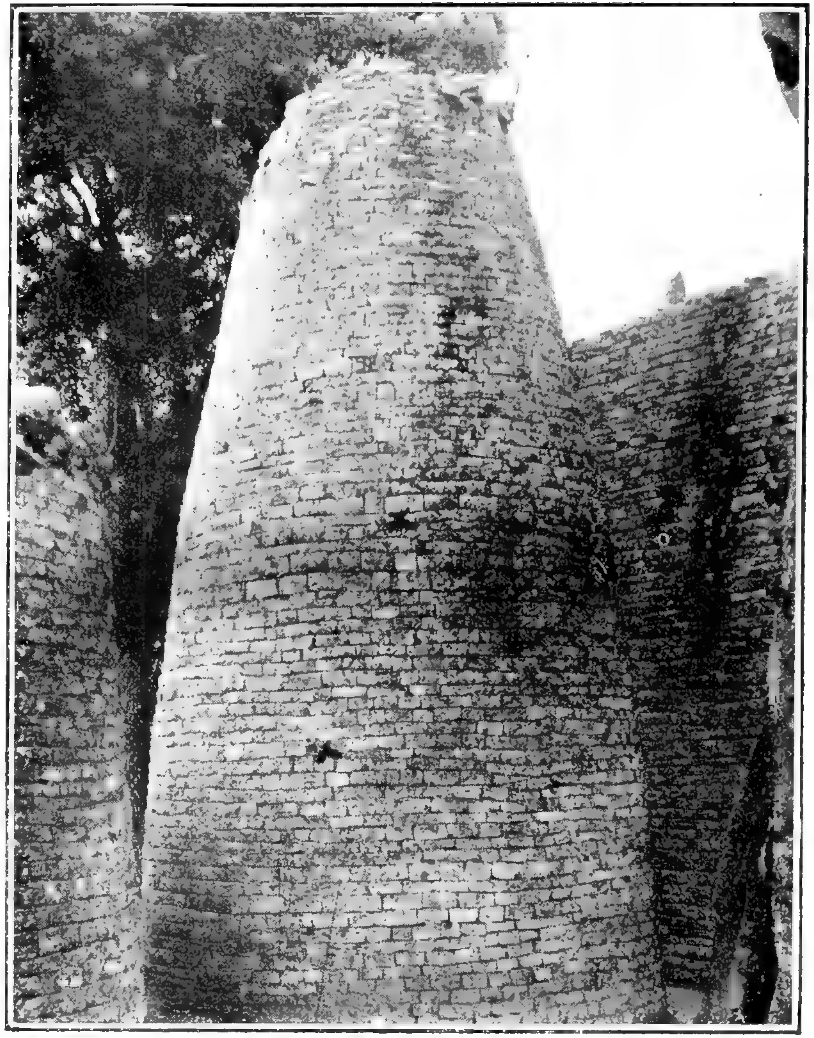
Rev. S. S. Dornan.—Rhodesian Ruins and Native Tradition.



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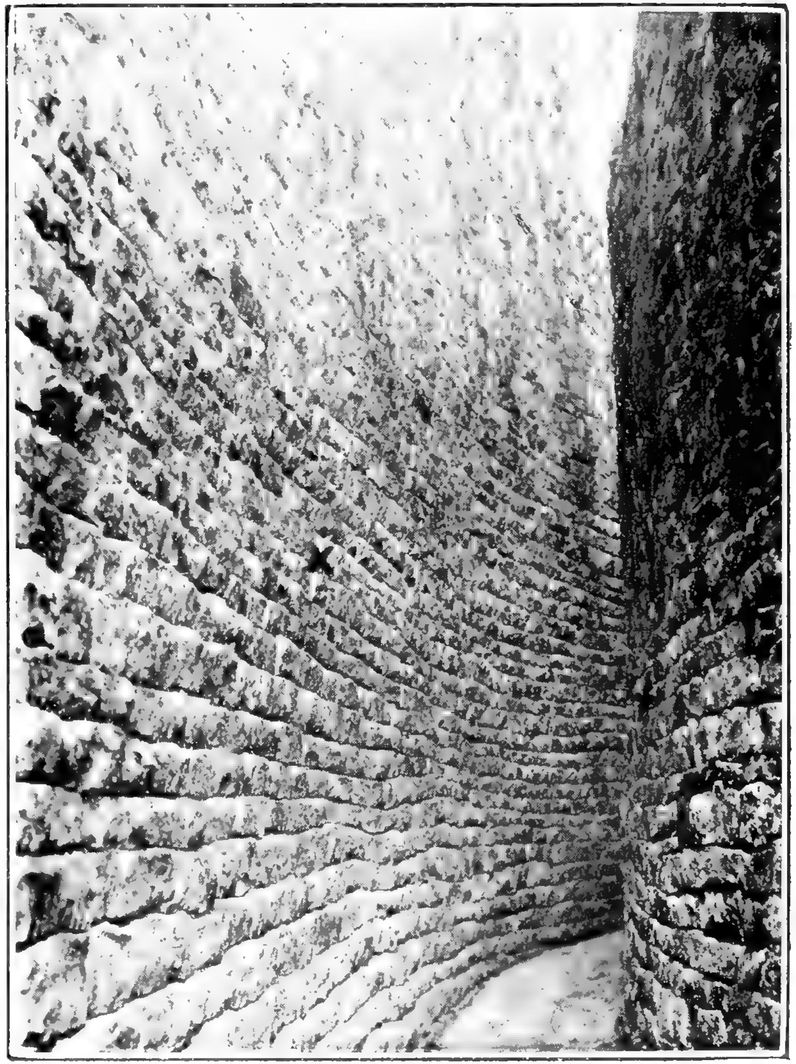

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Rev. S. S. Dornan.—Rhodesian Ruins and Native Tradition.

on the Klein Tati River, and I could see no signs at any of these places that the builders had worked from any definite plan laid down beforehand. The walls of these various buildings are ovals, and not even then are they uniform in height or thickness. They twist in and out in such a manner as to convince one they were built piecemeal. This is further strengthened by the blind courses and other indications of haste and want of intelligence. In fact, only their great thickness prevents them from falling into ruins. Signs of rapid decay are evident everywhere.

A more detailed description of the ruins at Selukwe may be of interest, as they have not previously been described. The hill itself is the middle one of three fairly high *kopjes* running east and west from the eastern bank of the Klein Tati River, and is about 200 feet in perpendicular height. The northern and western sides are precipitous, or very steep slopes. The rock itself is an outcrop of epidiorite, and is part of a large intrusion, covering several square miles of country. The walls are built of slabs and fragments of this rock. No special pains have been taken to dress the stones, which are of all shapes, but mostly roughly triangular or oblong. The rock is hard and tough, and it requires considerable force to detach a large fragment. The walls are built on roughly the same plan as Khami, but the stones are not so well dressed. Following the natural features of the hill, first a wall in the form of a retaining wall with a considerable batten has been built right round the hill. At the top there is a fairly high parapet. Between this and the hill the ground has been filled in with fragments and chips, and over that is a layer of ashes and refuse of various kinds. Very often the walls have been built up against projecting rocks, and these have been utilised for the platforms with the aid of earth and stones in very much the same way as at the Acropolis, Zimbabwe. Some of the terraces are as much as 30 feet broad, and as the hill is quite a mile in circumference the amount of labour needed to accomplish the building of such was immense. There are entrances here and there with traverses as at Khami, and the foundations of the huts are visible in several cases, built of the same kind of blocks as the walls. The hill must have been taken by assault, as the walls are pulled down at various points, and pieces of calcined pottery and rock are met with frequently, showing where the huts had been burnt down.* Near the top there is a second terrace similar to the first, but not so large or so well built. Every advantage has been taken of the defensive features of the hill. I cannot see any signs of great antiquity or of great skill in building, and if the hill were cleared of bush much of interest would be found. I cannot think that the hill was abandoned before the Matebele incursion in 1840. Where the buildings are better

* I found a portion of a grinding stone on this hill, similar to those of to-day.

they are not so much due to higher skill as better materials to work upon, and the builders seems to have preferred granite, as the ruins are better in the granite areas. Mr. H. B. Maufe, Director of the Geological Survey of Southern Rhodesia, informed me that the impression he got from an examination of Khami was that the blocks had been broken with iron hammers, and I can confirm this from other ruins, as when they are examined with a fairly strong glass, they seem to be quite fresh; too fresh to be really ancient. The hammers employed to break up the stone did not seem to have been very heavy, not heavier than modern native axes. The stones are far less weathered than one would expect. This feature of all the ruins that have come under my observation appeared to me to be a weak spot in the prehistoric theory.

In face of the internal evidence yielded by the buildings themselves and the confirmatory native traditions, I do not see how one can resist the conclusion that these ruins were built by a race of negroes, and most likely by the ancestors of those who still live in the country, and at no very distant date. I cannot see what is to be gained by refusing to the forefathers of the present Makaranga tribes, for the ruins are practically conterminous with the former distribution of these tribes, the very moderate degree of skill and patience needed to erect them. It is just as probable and equally scientific to assume that the old natives could, and did, attain a sufficient degree of intelligence and skill in building, than to postulate some unknown foreign race, who came from where is not clear, nor for what purpose, erected these structures, and then as mysteriously vanished, leaving no other trace of their presence. Such a method of explanation, however romantic or alluring, is only a modern example of the old fallacy *ignotum per ignotius*, a reversal of the process of evolution in respect of human culture.

Explanation of Plates.

Plate 15 *a*.—The summit of the Acropolis, showing small portion of excavation. (Photo by Rev. A. M. Filmer.)

Plate 15 *b*.—"Herringbone" at Zimbabwe. Photo by Rev. Neville Jones.)

Plate 16 *a*.—The excavations on the Acropolis. (Photo by Rev. Neville Jones.)

Plate 16 *b*.—Portion of valley ruins, with monolith in position in doorway. (Photo by Mr. M. Murray.)

Plate 17 *a*.—Makaranga girls near Zimbabwe. (Photo by Rev. Neville Jones.)

Plate 17 *b*.—Terrace at Selukwe, about 12 feet high.

Plate 18 *a*.—Conical tower, showing false courses of masonry marked with a cross. (Photo by Rev. A. M. Filmer.)

Plate 18 *b*.—Passage between outer and inner wall of "Temple," showing false courses of masonry marked with a cross. (Photo by Rev. A. M. Filmer.)

A FACTOR IN THE EVOLUTION OF PLANTS.

By Prof. Horace Athelstan Wager, A.R.C.Sc.

Water is of the utmost importance to all protoplasm, not only for structural purposes, but for all its chief functions. At the beginning of the evolutionary scale both animals and plants were aquatic. Water is taken into all plants by the process of osmosis. As plants became more complex the process of osmosis was extended to include not only absorption of water from without, but also the passage of water from cell to cell. It was this extension that enabled plants to commence a terrestrial mode of existence. Complexity could only increase if water conduction became improved. In this respect differentiation first appeared in plants in the form of a special part set aside for water absorption, that is, rhizoids, roots, etc. Then a special tissue for water conduction became differentiated. This consisted of cells in definite longitudinal rows becoming fused and forming long tube-like structures called vessels. These vessels were specially thickened in various ways, and many of the cross walls disappeared. Water appears to pass up such vessels, although still by osmosis from cell to cell, with more readiness than in ordinary cells—osmosis taking place through the parts of the vessel walls left unthickened. These vessels lose their protoplasm and become mechanically functional for water conduction. They pass right through the plant, and are continually being lengthened both at the apex of the stem and the apex of the root. It must be noted that these vessels never have continuous cavities. The length between cross walls varies to a great extent in different plants, but a millimetre may be considered long for such divisions. The vessels are produced in the first instance at the growing points, and are continuous right through the plant. In many plants the number of vessels so produced suffices for its needs. Now, it is well-known that these vessels, although produced for a definite purpose, can only function for a short time as water carriers. Why should these vessels, which act on a purely mechanical principle, so soon fall out of use or even fall out of use at all, or why did not plants, as it were, discover a more lasting kind of vessel? We must take it for granted that plants did the best imaginable considering all the difficulties that had to be overcome. However, seeing the distance that water travels in some plants, we are dealing with the most wonderful system of water conduction in the world. The explanation of the disuse of the vessels appears to be this. All water contains a certain amount of air in solution, the amount varying according to the temperature and pressure. Water passing up a vessel is exposed especially to variations in temperature, so that of necessity a small amount of air must come out of solution when the temperature of the water rises. This air cannot pass through the vessel, so that it collects in small bubbles in the segments of the vessel, whilst the water which gave it out passes on. As more water passes up, and as the temperature again varies, it is possible that the air is again taken into solution, but the final result is that more air comes out of

solution than is taken back into the continuous current. In this way bubbles of air must collect in the segments of the vessels. It must also follow that the bubbles slowly increase in size until the amount of air so imprisoned in the segments of the vessel interferes with its function. The time comes when the vessel is thrown completely out of action, and the vessel becomes simply full of air. The length of life of a plant, therefore, depends upon the length of time that its vessels can function as water carriers. The period of functional activity is obviously difficult to arrive at, but it is usually considered to vary from a few months to not much more than a year. We now know, of course, that the length of life of a plant is concomitant with its ability to produce more vessels. The special method by which this is carried on is well known. It is in trees that longevity, together with secondary thickening, has become most marked. The usual explanation of secondary thickening is that it takes place in order to keep up a supply of water to the increasing plant, or that the trunk of a tree increases in size in order to uphold the ever-increasing crown. Now, all forms of life possess great latent powers which can be brought out at any time. In plants this is shown by the power to survive unfavourable conditions, to recover from wounds, devastation by insects, etc. As vessels are permanent structures, stems that produce more vessels must, of course, increase in girth, and in the nature of the case the new wood produced would be likely to be more rather than less that already produced. The response to this would be that the latent powers in plants would allow for an increase in the foliage, so that as the wood increased the foliage would increase rather more in proportion. The crown of a tree, therefore, is the outcome of the latent power possessed by the tree, and is produced more as a response to the necessity of the tree to supply water-conductive tissue to replace that thrown out of action. In plants, in which more water is carried up proportionately, the quicker will the vessels be thrown out of action. This is the case with most annual herbaceous plants, *i.e.*, sunflower, dahlia, etc., so that secondary thickening is necessary in such plants. Plants that have no secondary thickening are in practically all cases short-lived, *i.e.*, monocotyledons. Many monocotyledons are perennials in so far that by storage in bulbs, tubers, etc., they can send up new shoots in each ensuing growing season, *i.e.*, lilies, asparagus, etc. Any monocotyledons with persistent stems, however, have a special mode of secondary thickening, *i.e.*, *Yucca*, *Dracæna*, etc. Ferns and grasses, with underground stems, continually send out new roots, whilst the stem dies away behind. Ferns, however, together with mosses and liverworts, have great powers of absorption of water by the leaves, and in most cases these plants can only live in damp places. The highest type of plant life is exemplified in a tree, and this state has been reached in evolution probably along the lines of water conduction. The physical property of water, therefore, of holding air in solution in varying quantities, has in all probability played an important part in the evolution of plants.

GAME AND BIRD PROTECTION IN SOUTH AFRICA: A SHORT COMPARISON WITH SOME OTHER COUNTRIES.

By Alwin K. Haagner, F.Z.S.

With the fast-vanishing herds of noble game animals in South Africa, and the indiscriminate catching and shooting of small birds in many of the districts, not to mention town lands, it is time more thorough and stringent laws for the adequate protection of game animals and wild-bird life were passed.

For the purposes of this paper it will be advisable to divide it into several portions, dealing respectively with the laws—both Government and municipal—and with reservations, whether Government, municipal, or private.

Game Laws.

In South Africa the Game Laws come under the Provincial Governments, and are different for each State. These provide for a closed season, and an open season for the shooting of game under a licence; the total protection of certain game for certain periods; and the limitation of certain species as regards the number to be shot on any one permit.

The Game Laws of South Africa are fairly good—some, indeed, as comprehensive as they can well be got, but the vastness of the country, together with the ignorance of the majority of the population in matters pertaining to natural history, make the task of game, and especially of bird protection, a very difficult one. It is next to impossible to have territories like the Pretoria, Rustenburg, and Waterberg "bushveld" adequately policed, and much illicit shooting and poaching goes on, year in and year out. Now and again the police make a capture and a prosecution follows, but from my own observations in the country named, I should think these convictions do not represent 10 per cent. of the poachers and illicit hunters. The Transvaal Game Protection Association has done its best, but it is sadly hampered by lack of funds. The South African farmer does not seem to realise the importance of the protection of game, and, as for bird protection, this is to him a blank or dead-letter. That he may the better understand and appreciate the possible benefits which can be obtained, I have taken the trouble to collect from various sources some statistics from other countries, chiefly the United States of America. Let him see what these countries have done in comparison with ours!

In America the bison, which roamed the prairies not many years ago in countless herds, to-day exists only in a semi-domesticated condition, by the grace of God and the strenuous efforts of the American and Canadian Governments to establish, and keep, herds of these noble-looking animals in the game reserves. Let this be a warning to us, and let us do our utmost to prevent a like occurrence with our splendid heritage, the noble game

animals of our sunny country. The bontebok is already in the sad position of the bison. The springbok and blesbok are now a mere shadow of what they were in former times. It is the duty of the present generation to see that the heritage left them by their forefathers is carried on for those that follow them, their children and children's children. I cannot do better than quote Dr. W. T. Hornaday, the Director of the New York Zoological Park, who in a well-illustrated pamphlet of the Zoological Society Bulletins entitled "Wild Life Preservation Number," published in June, 1909, says:—

As a duty which it owes to the people of America and to Science, the preservation of wild life is one of the three great objects to which the New York Zoological Society has constantly devoted attention and effort.

He then gives us 15 cardinal principles affecting wild game and its pursuit, which he proposed on 17th April, 1908, and called a "Sportman's Platform":—

1. The wild animal life of to-day is not to do with as we please. The original stock is given to us in trust, for the benefit both of the present and the future. We must render an accounting of this trust to those who come after us.

2. Judging from the rate at which the wild creatures of North America are now being destroyed, 50 years hence there will be no large game left in the United States, nor in Canada outside of rigidly-protected game reserves. It is therefore the duty of every good citizen, to promote the protection of forests and wild life, and the creation of game preserves while a supply of game remains. Every man who finds pleasure in hunting or fishing should be willing to spend both time and money in active work for the protection of forests, fish and game.

3. The sale of game is incompatible with the perpetual preservation of a proper stock of game; therefore it should be prohibited by laws and by public sentiment.

4. In the settled and civilised regions of North America, there is no real necessity for the consumption of wild game as human food, nor is there any good excuse for the sale of game for food purposes. The maintenance of hired labourers on wild game should be prohibited everywhere, under severe penalties.

5. An Indian has no more right to kill wild game, or to subsist upon it all the year round, than any white man in the same locality. The Indian has no inherent or God-given ownership of the game of North America, any more than of its mineral resources; and he should be governed by the same game laws as white men.

6. No man can be a good citizen and also be a slaughterer of game or fishes beyond the narrow limits compatible with high-class sportsmanship.

7. A game-butcher or a market hunter is an undesirable citizen, and should be treated as such.

8. The highest purpose which the killing of wild game and game fishes can hereafter be made to serve is in furnishing objects to overworked men for camping and tramping trips in the wilds; and the value of wild game as human food should no longer be regarded as an important factor in its pursuit.

9. If rightly conserved, wild game constitutes a valuable asset to any country which possesses it; and it is good statesmanship to protect it.

10. An ideal hunting trip consists of a good comrade, fine country, and a very few trophies per hunter.

11. In an ideal hunting trip the death of the game is only an incident; and by no means is it really necessary to a successful outing.

12. The best hunter is the man who finds the most game, kills the least, and leaves behind him no wounded animals.

13. The killing of an animal means the end of its most interesting period. When the country is fine, pursuit is more interesting than possession.

14. The killing of a female hoofed animal, save for special preservation, is regarded as incompatible with the highest sportsmanship; and it should everywhere be prohibited by stringent laws.

15. A particularly fine photograph of a large wild animal in its haunts is entitled to more credit than the dead trophy of a similar animal. An animal that has been photographed never should be killed, unless previously wounded in the chase.

If we substitute the word "native" for the word "Indian" used above, and the name of our country, we can apply these admirable principles to ourselves with advantage.

Let us now take a rough survey of the Game Laws in force in South Africa. It would be out of place to refer in this paper to those of the various Provinces at any great length, and it must suffice if attention is drawn to the more important features. In Major Stevenson Hamilton's book, "Animal Life in Africa," the Game Laws of most of the Provinces and States will be found printed *in extenso.*

Cape Province.—The Cape Administration issued a pamphlet, "The Game and Trout Fishing Seasons, 1915." This details the close seasons for the various districts, which varies from the 1st July, 1st August, or 1st September to 31st March, and from the 16th August to the 30th April, in the several districts. An ordinary game licence costs 10s.

In the Knysna Forest and the Addo Bush, elephants, buffalo and koodoo are protected, and may not be shot without a special permit from the Administrator. In the Oudtshoorn and Cradock districts herds of mountain zebra still exist, and are protected by a special permit for capture. Unfortunately, a number of permits seem to have been issued of late years, as I know of several shipments of mountain zebras to Europe by animal dealers. I note, however, with great satisfaction that no permits will be issued during 1915. In the Caledon and Swellendam Division, a few herds of bontebok still linger in a semi-domesticated condition, and are preserved by the praiseworthy efforts of the Albertyns and Van der Byls. Would that we had a few more like them!

The hunting of game after certain hours is prohibited in certain districts—for instance, between 6 p.m. and 6 a.m. in the Britstown, Mossel Bay, and Uniondale districts; from one hour after sunset and one hour before sunrise in the Worcester, East London, and Cambridge districts, etc. This is a regulation I should like to see in force in the Transvaal, as nearly all the buck-poaching in the bushveld is done at night, the nomadic Boers lying in wait for the buck after nightfall in the regular paths or runs of the animals.

The sale of game is prohibited in the Albany, Beaufort West, and Mafeking Divisions. All game is protected on the Government farms in the Clanwilliam Division. Royal game includes elephant, eland, zebra, buffalo, bontebok, blesbok, gemsbok, hartebeest, koodoo, reedbuck, wildebeest, and klipspringers,

which may not be hunted without special permission from the Administrator.

Transvaal.—In this Province the game is divided into two divisions for the purposes of the administration of the law, "ordinary" and "big" game. The former schedule contains the various smaller buck, hares and warthog, and includes the various varieties of game birds and water fowl. The latter schedule contains the larger and rarer forms of antelope, and the buffalo, as well as the crested crane, the wild ostrich and the pachyderms. No game may be shot without a licence by anyone except the owner or lessee of a farm. This costs, for ordinary game, 30s. for the whole open season, and 15s. for any one month during the open season. Big game can only be hunted on a big game licence from the Administrator, formerly costing £25, but now at such rate as the Administrator may deem fit. The exception given to farmers from taking out a licence to shoot *does not include big game*, so that in the Transvaal, at any rate, these noble animals are now virtually protected by law.

A game licence restricts the shooting of game to the open season only, which in the Transvaal extends from the 1st May to the 31st August inclusive. It can be made to restrict the number of any given species allowed to be shot, or the sex of such species.

The destruction of any particular kind of game can be prohibited from time to time; owners of farms are *not allowed* to shoot such prohibited species (as, for instance, springbuck were strictly preserved on the "Springbuck Flats" for a term of years). The reservation of game on private farms is a sore point with many farmers, and there are many, even scientific men, who advocate the total exception of the farmer from the game laws, so far as his own farm is concerned. I am very much opposed to this, as I think such an exception would sound the death-knell of many scarce species. Many a farmer has not the slightest interest in the antelope from a scientific, or even æsthetic, point of view. His interest is often limited to the meat or biltong he can get from the animal, and little does he care for such ideas as the perpetuation of a species. Apart from all this, in most of the Provinces there is a clause safe-guarding the farmer from the overstocking of his farm by game, and he has only to apply to the Administrator for the necessary permission to thin out his herds.

The sale of game meat in the Transvaal is only permitted under certain restrictions, and may be retailed only by a licensed butcher or market master under a special licence costing £3.

The export of game, whether alive or dead, trophies, horns and hides of game is only allowed under a special permit obtainable from the Administrator.

Rewards were paid for the destruction of recognised depredatory animals (classed as "vermin") ranging from 2s. 6d. for a silver jackal to £1 for a wild dog. These rewards,

however, have been suspended for the period of the duration of the war.

Utility birds (from an economic standpoint) are protected under the Game Laws, but I shall deal more fully with this under the heading of "Bird Protection."

Natal and Zululand.—The open season lasts from the 1st May to 15th August, a fortnight shorter than that of the Transvaal. The capture of game by any kind of trap or snare is forbidden. The use of the shot-gun is restricted to the smaller antelope only. Permits to shoot or capture the large game, or game within a reserve, are obtainable from the Provincial Secretary for a fee ranging from £5 upwards. An ordinary game licence costs £1 for an open season. Permits for the killing of smaller game will be granted to landowners free of charge for a period not exceeding six months, if they can prove that such game are destroying their crops. Permission may also be granted to residents and native chiefs to kill a limited number of head of game for food. The sale of game meat is also restricted, as in the Transvaal.

Bechuanaland.—The open season is from 1st March to 30th September. Large game is protected by a licence, costing from £2 for a fortnight to £20 for the full season. The resident Commissioner has the power to issue permits without charge to certain persons, such as *bona-fide* travellers, etc.

Portuguese South-East Africa.—Game was formerly very abundant in the Portuguese Territories, but has become considerably scarcer of late years, and the Portuguese Government have now prohibited the indiscriminate slaughter of game, and a permit is necessary, procurable from the Governor of the Province.

Orange Free State.—The Game Ordinance of 29th July, 1914, provides for the legislation of game-hunting much on the lines of the other Provinces. The closed season is from 1st August to 31st March. Shooting is prohibited on Sundays. There are also restrictions on the sale and exportation of game.

North-West Rhodesia.—A game licence costs £1 for small game. A special licence costs £5 for residents and £25 for non-residents. For larger game an Administrator's licence is necessary, which costs £50 and entitles one to shoot elephant, rhino, giraffe, eland, koodoo, mountain zebra, ostriches and white-back duiker. There are restrictions as to the number of certain game which can be killed under the special licence.

Game Reserves in South Africa.

In my opinion there are not enough reserves in the country, especially small reserves, where a particular species could be preserved. In the *Transvaal* we have—

(*a*) The large Game Reserves of the Sabi and Singwitzi on the Transvaal-Portuguese Border (under the care of Major Stevenson Hamilton, as Warden). These have been recently extended to include the area between the two reserves. Only

certain roads may be used for traversing the Sabi and Singwiti Reserves, and no firearms may be carried without special permission from the Warden.

(*b*) The Pongola Reserve, in the District of Piet Retief and (*c*) the town lands of Pretoria. Until this year there was also (*d*) a reserve in the Rustenberg District, which has been recently done away with, but all game has been protected by special enactment on all Government farms within the area of the old reserve, and police posts have been established at several points to enforce the regulations.

Natal and Zululand.—A large reserve exists in Zululand, which is under the care of Major Vaughan Kirby as Warden, and another smaller one at Giant's Castle, under Mr. Symons. In the latter a fine herd of eland exists. Certain regulations exist as to the management of the reserves, and the shooting of game, etc., for information on which we must refer the reader to Proclamation No. 221 of 1912 (Natal Province).

Cape Province.—Game reserves have been established in Namaqualand, Gordonia, and Kuruman Divisions. No shooting permits are granted to shoot in these. Forest reserves also exist, which require a special permit from the Administrator for royal game, and permission from the Forest Officer, besides the payment of a licence of 10s. per gun per day.

North-Western Rhodesia.—There are two game reserves in this large territory, one in the Diowa District and one in the Kafue.

Bird Protection in South Africa.

So far little has been done out here in this important work. The Transvaal Game Protection Association was instrumental in the Provincial Administration to enactment of a law on the the 6th April, 1915, prohibiting the hunting or destruction of certain birds on account of their general utility. This is Proclamation No. 20 (Administrator's) of 1915, and protects the birds set forth in the Schedule as follows:—

SCHEDULE.

General Utility Birds and Locust Destroyers.

English Common Nomenclature.	*Scientific Nomenclature.*
Stork, White Bellied.	*Abdimia abdimi.*
Stork, White.	*Ciconia ciconia.*
Starling, Wattled.	*Perissornis carunculatus.*
Egret, Buff-backed.	*Bubulcus ibis.*
European Roller Jays (Blue Jay)	*Coracias garrulus.*
Racquet-tailed Jays.	*Coracias spatulatus.*
Mosilikatza's Jays.	*Coracias caudatus.*
Purple Jays.	*Coracias mozambicus.*
Cinnamon Jays.	*Eurystomus ater.*

All birds belonging to the families Œdienemidæ, Glariolidæ, and Charadridæ, or the Order Limicolæ, including the whole of the plover species, and in particular the following:—

English Common Nomenclature.	*Scientific Nomenclature*
Black-winged Pratincole.	*Glareola melanoptera.*
Red-winged Pratincole.	*Glareola fusca.*
Dikkop or Thickknee.	*Œdicnemus capensis.*
Water Dikkop.	*Œdicnemus vermiculatus.*
Burchell's Courser.	*Cursorius rufus.*
Two-banded Courser.	*Rhinoptilus africanus.*
Crowned Lapwing.	*Stephanibyx coronatus.*
Blacksmith Plover.	*Hoplopterus speciosus.*

Cape Province.—In the Cape Province birds and their eggs are protected by enactment of the Provincial Council under Section 85 of the South Africa Act, 1909, at the request of any municipality. Birds were accordingly protected for a term of three years in the following town lands: Aliwal North, Aberdeen, Beaufort West, Bedford, Butterworth, and the native locations, Cathcart, Ceres, Cradock, Cambridge, Cape, East London, Kingwilliamstown, Komgha, Maraisburg, Montagu, Mount Ayliff, Port St. John's, Worcester, Walmer (Port Elizabeth), in all of which the various protected birds are scheduled, and Queenstown (all birds). In the Cape Province generally and the Transkeian Territories, all the so-called locust birds are protected. It is to be hoped that when the three years expire the protection will be extended for a further term. A Committee of the South African Ornithologists' Union might be formed and empowered to go through the schedules and correct them as far as they can do so with the present knowledge at our disposal. Under the Game Laws flamingoes are protected throughout the Cape Province until 25th May, 1916. Game birds are protected by close seasons in the various districts, which vary for each district, and so in some cases by total prohibition for a term of years.

Natal.—The species of guinea-fowl, francolin and bustard (korhaan), and dikkop are included in Schedule A (ordinary game) of the Natal Ordinance (No. 2, 1912), whereby they are protected by the same close season as small game.

The plovers are better protected under Schedule B (specially protected game), while the crested and stanley cranes are included in Schedule C, royal game. The young or eggs of game birds are protected by paragraph 22 of Proclamation No. 221 of 13th November, 1912.

Proclamation No. 33 of 1896 specially protected "certain insectivora and other wild birds." The schedule includes the locust birds, white stork, tick bird (red-billed ox-pecker), swallows, and wagtails.

Proclamation No. 200 of 23rd October, 1912, protects a long list of general utility birds as well as their eggs, and includes seed-eaters, barbets, bee-eaters, cuckoos, egrets, hoopoos, ground hornbills, gallinules, herons, hammerkops, flycatchers, flamingoes, and the species of ibis.

It will thus been seen that Natal and Cape Province are ahead of the other two Provinces so far as bird protection is concerned.

Orange Free State.—According to Game Ordinance, 1914, all game birds are protected by a close season from 1st August to 31st March. This includes, besides the francolin and guinea-fowls, the dikkop, waterfowl, plovers, and lapwing snipe. The taking of the young and eggs is also prohibited.

Locust birds are specially protected. Mr. C. McG. Johnston, the Secretary of the Orange Free State Agricultural Society, informs me that the Provincial Council have now completely protected the whole of the bustard and plover families in the Free State area, and that in consequence korhaan are becoming plentiful again in some of the districts. It is also thought that the protection of these birds is already mitigating the termite pest.

The South African Ornithologists' Union, which was founded in 1904, and whereof I am Hon. Secretary, has a Bird Protection and Migration Sub-Committee, but hitherto little has been done owing to the unsettled state of the country, politically and otherwise. But, as I stated in a pamphlet on the economic relations to man of the various South African birds of prey, little can be done by Legislature while the present ignorance on matters of natural history prevails in South Africa. What is the use of prohibiting the killing of certain birds, when the vast majority of the inhabitants do not know these particular birds from a crow or "*vink*"? We must educate them first, and to this end I wrote, in collaboration with Mr. R. H. Ivy, my "Sketches of South African Bird Life," of which the second edition is now in the press. This is profusely illustrated by means of photographs. The South African Ornithologists' Union was also instrumental some years ago in bringing about the issue by the Transvaal Education Department of well-coloured wall pictures of some of the more useful birds and migratory species. These are the lines upon which we have to develop, and the rising generation must be educated up to the principles which I have tried to expound.

The late Dr. Gunning, Mr. Austin Roberts, and Dr. Warren have each written popular articles upon the economics of South African birds in the *Transvaal* and *South African Agricultural Journals,* and more of such papers are wanted.

Game and Bird Protection in America.

Now let us for a moment glance at what is being done in some other countries in the matter of game and bird protection.

In America the game reserves, bird preservations, fisheries, etc., are under a Sub-Department of the United States Department of Agriculture, the "Bureau of Biological Survey," whose chief was Dr. C. Hart Merriam. Dr. H. W. Henshaw is now in charge, under whom Dr. T. S. Palmer is the assistant in charge of game preservation. There is a large staff of assistant biologists, who issue most interesting reports from time to time, such as an annual report on the game protection, pamphlets bearing upon "National Reservations for the Protection

of Wild Life," "Private Game Reserves and their Future," "Game Commissions and Wardens: Their Appointments, Powers, and Duties," "The Game Laws of 1911," "The Game Warden of To-day," etc. With a large staff of scientists, foresters, wardens, commissioners, etc., under an efficient departmental head, it stands to reason that the protection of game and birds must be nearly as thorough as man can make it. I quote, from the circulars of the Bureau of Biological Survey, some figures which may be a revelation to many in South Africa:—

National Reservations.—In 1912 the total number of reservations was 95, whereof 66 were under the Department of Agriculture, 12 under the Department of Interior, 9 under the Department of Commerce and Labour, 5 under the War Department, 1 under the Navy Department, and 2 others. These were made up as follows:—10 national parks, 5 national military parks, 9 national game preserves, 56 national bird reservations, 10 reservations for water birds, and 7 national reservations made game preserves by law. Some of these reserves were, of course, created for other purposes—as, for instance, the military parks and national monuments—but they now serve as bird sanctuaries as well. So far as actual game protection is concerned, we need only concern ourselves with the 10 national parks which serve as game reserves, chief of which is, of course, the famous Yellowstone Park in Wyoming, of 2,000,000 acres in extent. The total acreage of the 10 parks is given by Dr. T. S. Palmer at 4,320,490.

The Yellowstone Park contains a herd of the pronghorn antelope, mountain sheep, bison, deer, moose, bears, and beavers, and is said to contain the largest herds of elk on the American Continent.

The game is protected by comprehensive laws for the protection of wild life enacted in 1897.

Apart from the foregoing State Reservations, private game preserves have been established, including deer parks and enclosures for big game, unenclosed uplands for big game or game birds, and duck marshes or preserves. These are the property of private individuals, clubs or corporations.

British Columbia has now a game reserve of about 450 square miles in extent, situated between the Elk and Bull Rivers, and around Lake Monro.

I shall now quote Dr. Palmer:

> Game protection in the United States has been developed along somewhat broader lines than in other countries. Its object is not solely to preserve a few animals and birds to furnish sport for a limited class, but to protect and increase useful species for the benefit of the people in general. It preserves, not only game animals and game birds, but also birds of song and plumage and those which are beneficial as scavengers or as destroyers of injurious insects and noxious weeds.

He then goes on to detail the relation of the farmer to the Game Laws, and the direct and indirect benefits which he derives from such.

National Bird Preservations.—These consist mainly of small rocky islands or tracts of marsh land of little agricultural value, with a few exceptions, notably the Niobrara Reserve, Nebraska, which includes an area of from 10,000 to 12,000 acres. The birds on these reservations are protected by a special Act of Congress and by the State Game Laws.

Wardens are stationed on the more important reservations for the better protection of the birds. Not content with such a thorough Government or State supervision, the National Association of Audubon Societies, who are largely instrumental in the existence of many of the reserves, renders the Department of Agriculture much assistance and co-operation in protecting bird life.

Egypt and the Sudan.

In 1912 important steps were taken towards protecting the native fauna of Egypt by two laws, one of the 4th May, 1912, regulating the hunting of game; and law No. 9 of the 20th May, 1912, protecting certain birds useful to agriculture, a list of which is given. A Department of Zoological Service was formed, whereof the Director of the Zoological Gardens of Gizeh (Captain S. S. Flower) was put in charge, with Mr. M. J. Nicoll as Assistant Director. I am indebted to Captain Flower's annual reports on the Zoological Service for 1912 and 1913 for the information herein included.

Gazelles were protected in the Alexandria District by a Proclamation of 28th February, 1910, and under the above-mentioned law of 4th May, 1912, a proclamation was issued on 20th January, 1913, prohibiting the shooting or hunting of gazelles near Tel el Azouk without special permission from the Government.

Captain Flower gives us an account of the preservation and furthering of the colonies of egrets. He says that from 12 to 15 years ago no scene of Egyptian agricultural life was complete without these beautiful white birds in parties of 10, 20, or more, walking throught the fields searching for their insect food. For the sake of the long graceful plumes which the egrets develop in the nesting season, they were systematically shot off in colony after colony by the plume-hunters. This was the case of the heron in Australia until the Government intervened at the instigation of the Ornithologists' Union. Egypt has now taken strong measures to protect these beautiful birds, with exceedingly satisfactory results. Captain Flower says that in 1912 only one breeding colony remained in Lower Egypt, which would also have been extinguished but for the protection of the Government.

Over 500 young birds were reared under natural conditions, but under the care of a watchman of the Zoological Service.

Artificial colonies were started in various places.

Hungary.

In this country economic ornithology plays an important rôle, so important that a special branch of the Agricultural De-

partment exists, termed the Royal Hungarian Bureau of Ornithology. This has been for years under the direction of Dr. Otto Herman, who has made migration his special study. The bureau issues a comprehensive annual report dealing with the migration of birds in Hungary; the food of birds, which receives the special study of a couple of the assistants, or staff; the progress of bird protection, etc. The members of the staff collect an enormous amount of data as to the insects and other food eaten by birds with a view to obtaining an accurate insight into the economic value of birds in regard to agriculture—*viz.*, the species of noxious insects and harmful weed-seeds which the birds eat—and so the exact status of each bird in relation to agriculture is eventually arrived at. Not only are birds of undoubted or proved economic value protected by law, but all sorts of devices are adopted for their increase and well-being—as, for instance, food shelters in winter, where the birds may obtain both shelter and a regular supply of food placed at their disposal by man; artificial nesting places in the shape of hollow boxes, hollow trunks, etc.

In concluding my paper, let me quote the following paragraph from the interesting book, "Birds Useful and Harmful," by Dr. Otto Herman and Mr. J. A. Owen:

> The question of usefulness and noxiousness of birds during the whole of the Nineteenth Century was treated only approximately upon the assertions of authorities. When, later on, Congresses began to embrace the cause of bird-protection and the question of the usefulness and noxiousness of each species assumed a rôle of the first importance, it turned out that there was no firm basis upon which to rely, in passing judgment. Eminent ornithologists were often at variance with regard to the usefulness or noxiousness of a particular species.
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> Where Nature is intact, the number of birds is automatically regulated in accordance with the natural development of their surroundings.
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> The conception of "Useful" and "Noxious" are merely human ones, and man can, by cultivation, or the contrary, alter the normal conditions, and may consequently, modify the character and habits of birds also. Agriculture on a large scale, modern forestry, the draining of territory—all these things alter the fundamental conditions of animal life and in consequence of bird life also; and if these modifications in respect to birds are injurious to man, it is in the interests of man to adapt them artificially for the benefit of birds; and if by cultivation, man deprives useful birds of their natural nesting facilities, he ought to provide them with artificial ones.

Tobacco Ash.—In view of the serious shortage of potash compounds, which is now being experienced all over the world, Mr. B. A. Burrell draws attention in the *Chemical News* to the fact that the tobacco and cigars consumed in the United Kingdom during the course of a year yield a total of about 13,400 tons of ash, containing 2,672 tons of potash, or the equivalent of 21,376 tons of kainit, a quantity worth £51,000 before the war, and now worth three times as much. He therefore urges the organised collection of the tobacco ash which is now being wasted.

MEDICAL INSPECTION OF SCHOOLS IN RELATION TO SOCIAL EFFICIENCY.

By Christian Frederick Louis Leipoldt, F.R.C.S., L.R.C.P.

The medical inspection of schools presents so many interesting points for discussion that it is difficult to select any special aspect of the subject for detailed consideration without appearing to lay undue stress upon the value of a component part of an all-round valuable and important whole. All will admit the intrinsic importance of the medical inspection of schools; all will agree that no branch of social, educational, or medical work is strengthened by standing by itself, but only by its co-partnership with correlated work; and, finally, all of us will readily confess to the creed that there is no real best where the degrees of comparison are so unequal as they are bound to be in any work that is rudimentary and pioneering. School medical inspection is, to some extent, yet in its embryonic stage. It is true it has already been in working, in some countries, for more than a decade, but when we consider it in relation to broad questions of public health and national efficiency, we find that it has hitherto been largely haphazard. The Legislature has, as it were, made a jump into the middle of a problem which should have been attacked on its outworks. We started with the seemingly axiomatic assumption that where the State imposes obligation it must help those who are unable to fulfil their civic duties. In a phrensy of fine altruistic philanthropy we plunged into medical inspection and supervision of schools, with all their attendant difficulties, and added communal obligations. Let us be grateful for that. One step in the right direction counts far more than a parallelogrammatic circumvallation of the whole objective. But siege engineers have a definite aim, and the laws that guide them are not fixed but fluent, as Vauban showed. Above all, they have in view two objects to be achieved—thoroughness and efficiency gained with the minimum of energy expenditure. In England, however, to cite one instance of an almost universal tendency, the State has disregarded Vauban's rules, and by a curious gymnastic effort, highly creditable to its agility, but hardly conclusive proof of its logicality, it has started progress in the middle instead of at the beginning. For it seems to me to be wrong to suppose, and to act on the supposition, that the State is concerned with the health of the growing citizen solely when such health, or the want of it, is a factor in estimating the degree to which a child can respond to the educational call made upon him by an Act of Parliament that prescribes school for every young citizen between the ages of five and fourteen. The health of the child concerns the State directly, inasmuch as it is the well or ill being of a unit of the community; indirectly, because the safeguarding of the sanity of the mass of young citizens safeguards at the same time the sanity of the race, and consequently the economic welfare of the nation. The obligation on the State is far

greater than is generally admitted by schemes of medical inspection of schools that deal, for the most part, merely with children of school-going age. It is the obligation to ensure physical efficiency in every child. To be strictly logical, the State should medically inspect every citizen. In other words, school medical inspection should be a branch of a State service of health, linked up with the department that controls the drainage and public health measures generally.

Prevention of physical defects in infants before they are of school-going age is in general easier and better than prevention later on. Nor is it sufficient that the child should be examined when he leaves school. The State should follow him up. It should see that he is placed in an environment calculated to ease instead of adding to whatever burden parental indiscretion or natural insufficiency has thrown upon him; it should attempt to supervise his life in these surroundings, and should offer him facilities for correcting new defects that arise through industrial or economic causes.

I think it is this aspect of school medical inspection, in its broad relation to social efficiency, that I may preferably submit for consideration, conditioned by the suggestion that it is not the only, although possibly the most important, aspect of the work that the Education Department of the Transvaal Province has recently initiated.

Perhaps I may, as a preliminary, indicate what are the basic requirements of any scheme of medical inspection of schools that aims at the practical, as apart from the purely theoretical, improvement of the children of the race. In the first place, it is essential that such a scheme should be co-ordinated to the existing system of education, and make due provision for local conditions and circumstances. The decentralisation that obtains in France or Italy is, for example, quite impossible in the Transvaal or in New South Wales, where medical inspection of schools must, for the present at least, be under the direct control of the central departmental authority, and not delegated to the local authority until such local authority is in a position effectively to superintend its administration. Indeed, it is questionable if certain aspects of medical inspection of schools can adequately be visioned from a purely local, one might almost say, from a Medical Officer of Health's point of view. Take, for example, the investigation of and the provision for mentally defective children. The percentage of such children in scattered rural areas is usually low, but for the whole Province, and, moreover, for the entire Union, it is high enough to warrant special recognition, leading ultimately to precautionary or remedial treatment on a scale which necessarily will involve capital expenditure that cannot be debited to local areas, but must be borne by the whole Province, and perhaps ultimately again by the Union. Next, take the matter of the incidence of infectious disease in schools. At present it is regarded as purely a matter of local interest in which the Medical Officer of Health for the district is primarily

concerned. Routine school inspection in large areas such as those controlled by the London County Council has, however, fairly clearly demonstrated the fact that systematic investigation by school doctors and careful scheduling of schools on a basis of liability to infection tends to limit the spread of epidemic of measles and scarlet fever, and to some extent also of diphtheria. Bluntly stated, if you know the percentage of immunity in certain schools in a specified district, you are far better able to control the spread of a disease in that district than if you did not know how many children were potential infection carriers. Where the percentage of immune children is unknown there is no alternative to school closure, a course of action that necessarily entails complete dislocation of the educational machinery in that district, and that by no means warrants the supposition that the epidemic can be limited or checked, since it is now fairly well established that in such diseases as measles and whooping-cough extra school infection is probably as potent a factor in spreading the disease as is class infection. Local School Board areas are, from the point of view of the epidemiologist, arbitrarily demarcated in the Transvaal Province, and unless the data with regard to immunity are collated with those of neighbouring districts, it is unlikely that they will prove of much practical value should an epidemic of infectious disease break out. I do not by any means minimise the importance of the work now being done by local Medical Officers of Health, but it must be admitted that such work will be greatly aided, and its practical value greatly enhanced, by the complementary work of the school doctor centrally conducted and regulated.

Further, it is necessary that the school medical officer shall be directly responsible to the Education Department, no matter whether such a Department is controlled by the Provincial or by the Union authority. This is the principle which has been adopted by the English Board, where the Chief Medical Officer, while working in close harmony with the officials of the Local Government Board, preserves an independence of function and control that has had the most satisfactory results so far as improvements in the hygiene of the national schools are concerned. It is of even greater importance in this country, where decentralisation, to the extent obtaining in Great Britain, is at present impossible.

Secondly, the important essential is that any scheme of medical inspection of schools for the Transvaal Province, or, indeed, for any community, shall concentrate its main attention upon the removal of defects discovered in school children at the routine inspections. The mere statistical elaboration of figures showing the urgent need to cope with juvenile invalidity serves no useful purpose in a civilisation that already recognises the desirability of dealing with such invalidity on logical lines, and is therefore largely a waste of time and of energy.

Dr. Hackworth Stuart, Medical Adviser to the Hanley

Education Committee, has put the case succinctly when he remarks:

> Statistics of defects in the school population are not only plentiful, but have done their work in securing powers to take the first steps in the direction of having these defects dealt with. It was not to enforce the compilation of national pediatric statistics that educationists have pleaded the cause of inspection. It was not to satisfy an appetite for figures, or to know which country has the bulkiest babies, that the long-suffering ratepayer hailed, without protest, the prospect of a further rise in the price of citizenship. Let us preserve a fitting proportion between productive work by skilled observers and figure compiling by less skilled workers. Let statistics be relegated to their proper subsidiary place in this connection, and their chief function be to indicate the methods of inspection which are most productive of resulting remedial action. The vital need at present is to get to work on the existing mass of disease in the schools, by means of inspection, by enlightening the parents, and by encouraging them to act.

This is the proper view to take of medical inspection in a country where statistics of juvenile invalidity are already available, but it must be slightly modified in a Province such as the Transvaal, where we have no data to permit of a really scientific comparison being made between the normal child in our schools and the normal child in schools in England. Some of the pioneering work that has been done elsewhere must fall to the lot of the school doctor here, in his own interest, because he needs a basis for comparison, and in the interests of the children and the community, because we are faced with diseases which do not confront the educationist in Europe, with malaria, with bilharziosis, and with endemic typhoid fever. But we have this advantage, that we start without the handicap of professional and popular prejudice. I believe I am right when I state that in this Province at least most educationists and medical men cordially approve of the principle of medical inspection of schools, and that there is practically a unanimous desire to co-operate and assist in the working of any scheme that promises to deal with the matter in a practical way. We have, further, the advantage that our juvenile population is comparatively small in numbers, that we possess a central authority, and that our schools, both primary and secondary, are essentially democratic and peopled by children from all grades of society. Against these are the disadvantages that many of our schools are in small rural areas, difficult of access, with a scattered school population under widely differing economic conditions; that we have no proper basis of scientific comparison for our normal children; and finally, that our resources of treatment, in contrast with those existing in England and elsewhere, are limited. It is fairly obvious that it is in our interest to concentrate upon the practical, and to make the purely scientific aspect of school medical inspection a secondary consideration. Yet it is desirable that scientific data, for purposes of comparison, should not be neglected. We need an anthropometric survey of our population, and school medical inspection offers a means of obtaining a survey of the juvenile section at least. The problems that need investigation

possess not merely an abstract scientific interest, but have an important bearing upon our social, economic, and racial evolution. In the United States important data have been obtained with regard to the prevalence of hook-worm disease among school children, and measures are now being adopted to cope with this plague, which should considerably improve the economic efficiency of the industrial population in the southern States. In the northern districts of this Province, we have a disease whose incidence is as great as that of hook-worm disease in America, and whose effects upon the health of the growing children of our population are, from the point of national efficiency, most pernicious. This is malaria. I have had the opportunity of noting the detriment caused by this disease in school children in two districts, and I confess that it has been a most unpleasant and saddening revelation. In the district of Pretoria we have another disease, red-water, or bilharziosis, which, although far less openly detrimental to the school efficiency of the children, is probably responsible for some degree of deterioration, and, in certain serious cases at least, undoubtedly affects the wage-earning efficiency in later life. There are, further, the many defects of early childhood, preventable or removable, that one meets with during routine inspections—defective teeth, causing constant absorption of poisonous products, gastro-intestinal defects, imperfect vision, bodily deformity, defective hearing, malnutrition and anæmia. All these must have an important bearing upon the national physique, and must, therefore, be dealt with as speedily and as radically as the means at our disposal allow. Moreover, we have surely some obligation to investigate the effects of certain of our industries and occupations upon the development and physical and mental evolution of our growing citizens. It is not merely a question of finding out by how many centimetres our girls and boys fall short in stature when compared with children of a similar age in Queensland or Canada, by how many decimals of a kilogram they differ in weight from children elsewhere. Interesting as these data are from a purely anthropometric point of view, they are insignificant and of little value unless they supply us with information that we may adapt to practical use with a view to improving the conditions which are the primary causes of racial deterioration.

In the third place, medical inspection of schools must stimulate public and parental interest in problems of juvenile hygiene and social efficiency. Without such interest its efforts will be barren of useful collective results, devoid of that driving force that creates progress in spite of great obstacles in its way. Especially in a new country, where the means of communal instruction by precept and example for the population is not so apparent as it is in an older civilisation, is such stimulation of popular interest most necessary.

The creation of a health conscience [remarks a School Medical Inspector of Victoria in his last annual report] of a sort of extra sense —sanitary sensitiveness—will eventually, by its preventive value, prove

the best and most enduring of our efforts. Legislative action, enthusiasm for reform, individual strivings, all wait on a public desire for health progress, an uplift that may come only with a new generation—the generation at present in our schools. Hence, the teaching of hygiene in schools, though of little direct value at present to the community, is nevertheless educationally of vital and immediate importance, for as the years pass by increasing waves of hygienically-disposed minds are entering the ocean of our civilisation to remedy the stagnation of ignorance and superstition. More and more, teachers will be on our side as to the value of fresh air; but above all the children of the open-air class-rooms and schools will grow up living examples and missioners of the gospel of fresh air. Every swimmer taught in our schools will revive in our nation its lost desire for the water and remove its present dislike of contact. Every Australian boy and girl growing up will regard no longer as a menace, but indeed as our finest possession, the glorious sunshine of this southern continent. Yet to-day the three things most feared are fresh air—draughts—cold water, and sunshine—sunstroke. These fears are as visionary and as unreal as former beliefs in witches or in fetishes—beliefs even more firmly held, yet now exploded.

I quote this paragraph because, with all due respect to our own community, the criticism is singularly apposite when applied to us. In our schools, too, we see filthy children, verminous heads and bodies, and disease bred by want of cleanliness, fear of cold water, and exclusion of sunlight and air. These three factors are responsible for more ill-health in our schools than are under-feeding or infectious disease. "My people are destroyed for lack of knowledge!" sang the prophet Hosea, echoing his predecessor, Isaiah. It needed epidemics of cholera and typhus to bring something of this knowledge to the public in England; we, fortunately, have had no blight severe enough in its national destruction to instil the commonplaces of sanitary science into our people. School medical inspection, if its object is to increase national efficiency and be of real value to the community, should forestall plague and fever as educative forces.

Finally, school medical inspection must strive to promote the betterment of industrial, domestic, and economic conditions which adversely influence the rising generation. Its work in this direction is intimately connected with its duty as an educative factor in matters of public health, and it can only achieve useful and practical results by investigating problems and co-operating with the health authorities. I may allude to the good work that has been done by school medical officers in connection with juvenile employment and vocational training both in England and in Italy, and by the stimulus which certain investigations by such officers have given to improvements in factory legislation. The work must be largely indirect, but it must be grounded on patient and solid research; the employment of the method of residues, which students of Mill still regard as a legitimate way of scientific investigation, will not do. As our economic conditions improve and our population increases, we shall be faced by new problems of work and industry, and their influence upon the evolution of the race. At present we have already certain questions that have hitherto been discussed from a purely political or economic, rather than from the sounder sociological aspect—the

question of the poor white, and the almost more important problem of masked pauperism presented by units of the community following certain underpaid occupations in rural and urban areas. The effects of these factors of poverty, disease incidental to occupation or to residence in unhealthy areas, and defects due almost directly to preventable ignorance, uncleanliness, and neglect, upon the physique of the growing generation can hardly be estimated at present with any degree of scientific precision, since we entirely lack the data for comparison. But as school medical inspection progresses, such data will accumulate, and will prove of immense value when these matters come under discussion in the future.

Such, then, are to my mind ,the essentials of any scheme of rational medical inspection of schools that, with a broader purview and a wider sense of its obligations, visions its work as a systematic attack not upon isolated defects discovered at school, but upon the root factors that account for national inefficiency due to preventable disease. It is impossible to deal at length with the manner in which it is proposed to ensure that these essentials shall be inevitable concomitants of any scheme elaborated for the Transvaal, but I may briefly sketch the general lines upon which it is suggested that medical inspection of schools should proceed.

With regard to the first essential, co-ordination with the central authority, we have started squarely, inasmuch as we have made medical inspection of schools an integral part of the functions of the Department of Education, and have not divorced it from the central authority by pigeon-holing the new service into another Department. The medical inspector of schools is now one of the departmental inspectors, directly responsible to the department for carrying out a scheme which has been drawn up after consultation with the departmental officials, and with due regard to local and departmental necessities. This prevents overlapping, obviates friction, and maintains unimpaired the functional integrity of the new service on the same basis as that under the English Board of Education. Matters of public health affecting local communities are dealt with in consultation with local medical officers of health, whose authority, in their own districts, must be supreme. Unfortunately there are still many districts where no local medical officer of health exists, and where the local district surgeon has a kind of semi-official authority, with usually no power to enforce it. Questions of procedure during an outbreak of infectious disease in such unserved districts present certain difficulties which must remain at present until the public health service in this country is controlled on scientific lines by a strong central authority. The want of such central control is one of the difficulties that school medical officers in this country will have to struggle against. Another difficulty is the absence of any legislative sanction for the work they are expected to carry out, and the dual control that now exists in some districts in consequence of the loosely-framed regulations

governing the procedure in certain public health questions. These difficulties one can meet with patience, fortified by the reflection that the service is new in this country, and that South Africa as yet does not possess a public health conscience in the true sense of the term. Once this latter mentor is aroused, the public will not tolerate a state of things that allows the Government to make game preservation and forest conservancy matters of more vitally national importance than the health of its citizens.

With regard to the second essential, it is proposed to deal with defects discovered at routine examination as promptly and as adequately as our somewhat limited means allow. We have no hospitals in the European sense of the term in this country; our institutions for the sick are either nursing homes for paying patients or pauper asylums analogous to the much-maligned and unpopular "infirmaries" in England. A child whose parents cannot afford to pay for medical or surgical treatment—and please remember that such inability to pay does not mean pauperism in the sense that it implies in England, where the rates charged for such treatment are far lower than here—must at present be either left untreated or must apply to the magistrate for treatment as a pauper. Add to this the fact that our hospitals do not possess out-patient departments which are worthy of the name, and that they serve white and coloured patients at the same time. For obvious reasons I refrain from discussing the subject of the efficiency of these institutions. My point is merely that if it is practically unsound to send defective school children to hospitals in England—a matter on which there exists almost unanimity of opinion—it is still less sound to send them to hospitals here. In England and in Australia—where hospital facilities are better than they are here—this problem of the treatment of defective children has been solved, I believe, on economically sound lines, and certainly on a basis that is practically effective—by the establishment of school clinics and travelling school hospitals. The same alternative to hospital treatment presents itself here, and in the scheme for school medical inspection in the Transvaal provision is made for the establishment of school clinics, travelling dental clinics, and probably a travelling hospital. Even at present the medical inspector is forced to take with him a supply of drugs and tonics, and the school nurse a supply of dressings and minor essentials, to deal with urgent cases on the spot. School clinics, while practicable for the larger centres, are out of the question for small rural areas; in such we must have a travelling hospital, peregrinating around its area once every year, and dealing with all defective children within that area who cannot afford private treatment or—and this is a point I would lay some stress upon—who prefer, for payment, to be treated by the specialists attached to the hospital. Concentration upon this important question of treatment is most desirable in view of the grave defects that arise through neglect of such defects, and personally I should much prefer to see the facilities for treating defective children extended to see-

ing the staff of inspectors augmented by assistants. An increase in the nursing staff is indispensable, for the school nurse is, and must be, a most important adjunct to any scheme of remedial treatment of defects. It is possible to dilate upon the question, and to point out the good work that has been done in Australia upon lines similar to those proposed for this Province, but the reader will doubtless fully realise the intrinsic interest of the matter, and expand these arguments at his leisure.

I pass to the third essential—the stimulation of public interest in the work, the creation of a public health conscience. It is proposed to attack this side of the matter directly by lectures to parents and teachers, and to the public at large, and indirectly through the influence of routine school inspection upon the children themselves. The value of a good school nurse's example is, so far as the children are concerned, incalculable, and the Transvaal is fortunate in its first school nurse, whose tactful and simple service in this respect has been productive of the happiest results. Ignorance, more than wilful neglect, is responsible for much of the misery of children in this Province, and a part of this ignorance at least the school nurse and the school doctor can efface by judicious and kindly talks. The travelling hospital, with its magic lantern and set of slides, should prove here, as it has proved elsewhere, of signal service. To interest the teachers alone will be an immense means of advancing the cause. I look forward to the time when every school in this country shall be able to have its school journey—probably the most important asset that the school doctor has at his disposal practically to inculcate the elementary rules of sanitary art and science–its school garden, and its regular class in domestic hygiene, and the care of the body. But before these reforms are possible, it is imperative that our locally recruited teachers are themselves educated to recognise the supreme importance of attention to these points. At present—I say it with regret and with a full consciousness of my responsibility—it appears to me that in some schools the teachers more than the scholars stand in urgent need of a simple lesson on the necessity for cleanliness and fresh air.

Finally, we have the fourth essential, that school medical inspection must endeavour to promote the amelioration of domestic, industrial, and economic conditions that adversely affect the rising generation. Obviously, it is much too soon to outline the manner in which we in the Transvaal can usefully deal with the various problems that confront us, for we lack, as yet, the data to enable us to form definite conclusions for constructive effort. Patient research and investigation must precede any trial, and it is possible that we shall have to experiment, and lose money and energy over the trials, before we achieve results that are enduringly satisfactory. Once more I may refer to the mentally defective child, the *moron* who is incapable of concentrating his mind and of reaching a stage of development sufficiently high to fit him for anything above the simplest employment in this complex civilisation of ours. At present we

deal with them on purely repressive lines, just as we deal with the native criminal, and with as little effect. Indiscriminately we lump together the abnormal child, who through environment or direct parental education becomes a potential criminal, and the *moron* and mentally defective child, who through ante- or post-natal causes entirely beyond his control or ours is an utterly irresponsible being. The one should be dealt with on what are, after all, fairly well-known rules of modern penology; the other needs much more careful study, and what we are to do with him is a problem that will have to be very carefully discussed. Special schools, farm colonies, and special legislation to follow up the work of these institutions and to prevent it from being wasted—all these will have to be considered, and in their consideration, I venture to think, the information and statistics collected by the medical inspectors in the schools will weigh to influence the final decision.

Lately I have been privileged to supervise the medical inspection of all the burgers recruited for the various commandoes in the Transvaal Province, and I have been struck, in collating the reports on these inspections, with the fact that the percentage of men rejected for preventable and remediable defects is far higher than it is in conscript armies in countries where medical inspection of schools has been in vogue for some years. Above all, it was strikingly shown that the percentage of defectives was far higher than the percentage registered during the inspections for peace training. I ascribe this difference, which is too high to be wholly natural, to the laxity shown at previous examinations, and to the inexperience of the examiners in regard to the nature of certain defects. Whatever the cause, it is clear that there is a large percentage of our adult population suffering from remediable and preventable defects that appreciably affect their wage-earning capacity, and consequently the national efficiency.

I started this paper by insisting upon the larger obligations of the State; I conclude it by suggesting that here in this country, where we already possess, to some extent, the machinery for the inspection of the adult males, school medical inspection should be linked up, on the one hand with the voluntary inspection of children before school-going age, and on the other with the enforced inspection of at least all males between the ages of 16 and 45. This latter inspection should be carried out by specially qualified officers appointed by the Defence Force, who should have access to the school medical records of the recruits they examine. In this way we have the nucleus of a proper anthropometric survey ready at hand. It only needs co-operation and attention to develop it, by means of accretion, into a real national service of health.

"LOOG AS"; OR, THE ASH OF THE ALKALI BUSH.

By ARTHUR STEAD, B.Sc., F.C.S.

There is a plant, *Mesembrianthemum junceum*, which grows luxuriantly in many of the Karroo districts, *i.e.*, the districts of Middelburg, Colesberg, Hanover, Richmond, Britstown, Victoria West, Prieska, Carnarvon, Beaufort West, Fraserburg, and De Aar. The plant attains quite a respectable size, it being not uncommon to see bushes of about three feet in height and four to five feet in diameter.

It is frequently stated, in reference to this bush, that it is killing off the useful herbage of the veld; but probably this is a case of a bush being able to thrive under soil conditions which do not permit of the growth of the plants useful for fodder purposes, which it is supposed to be destroying. Sporadic attempts are made to eradicate the weed, but without much success. It is cut off near the ground and does not grow again, but, being a prolific seeder, many young plants usually spring up for every one eradicated.

The cut-off bushes are collected and burnt to an ash, which is put in bags so as to make up from 140 to 150 lbs. in weight. The best time to burn is from April to May or June.

Last winter the Middelburg municipal authorities burnt 692 bags of ash, firstly to give employment to out-of-works, and secondly, to attempt to clear a portion of the commonage, of which the bush had taken almost complete possession.

The cost of burning, bagging and cartage worked out at approximately 2.2 shillings per bag of 140 lbs. of ash produced. "Loog as" as at one time very much used in making soap. That was before the advent of railways and caustic soda. The latter has now apparently almost totally supplanted it, with the result that one now seldom receives an offer to burn one's ash bushes on the halves, or, indeed, on any other terms, as was formerly the case.

In order to ascertain its manurial value, a sample of last year's burning was obtained. On analysis it was found to contain:

Moisture	5.3	per cent.
Insoluble inorganic matter	37.0	,,
Water soluble Potash (K_2O)	22.2	,,
K_2CO_3 32.59 per cent.		
Water soluble Soda (Na_2O)	11.2	,,
Na_2CO_3 19.15 per cent.		

In addition, there were small quantities of soluble phosphates, chlorides, and sulphates. The alkalies are present almost entirely as carbonates.

The manuarial value of this material calculated on its potash contents only is about double that of the normal price of kainit.

At the present time, however, it is impossible to obtain quotations for potassic fertilizers of any description owing to

the fact that the output of the Stassfurt mines is no longer available on account of the naval blockade. The present market value of "loog as" as a source of potash for agricultural purposes is doubtless, therefore, more than twice the normal value of kainit. The attention of manure merchants is directed to "loog as," in the hope that they will be able to make up in some measure for the temporary loss to the world of the output of the Stassfurt mines.

In Middelburg alone it is estimated that, without any further burning operations, there are at least 100 tons of the ash available for immediate use. It must be borne in mind that the carbonate form has considerable drawbacks from the manurial point of view. Its use in the drier localities is not to be recommended, except on soils which contain soluble calcium salts, but there would seem to be no reasonable objection to its general use in the more moist districts.

It would prove an excellent source of potash in the case of soils which have a tendency to acidity, and is therefore likely to prove valuable for the grain-growing areas in the Western Province.

With regard to its use as a soap-making agent, its local value appears to vary between 3s. 6d. to 5s. per 150 lbs.

The following recipe is given for its use as a soap-making agent:—

To two buckets of ash add four to five of water. Then either boil for an hour or two or allow to stand, with occasional stirring, for 48 hours. Whichever method is adopted, the resulting solution is allowed to clarify, after which it is drawn off.

The solution is tasted by wetting the finger and applying it to the tip of the tongue. If a burning sensation is experienced, the solution is of sufficient strength; if not, a larger quantity of ash must be employed.

A bucketful of the extract is then placed in a kaffir iron cooking pot together with 30 lbs. of fat. The whole is brought to the boil and maintained at that temperature for several hours during each of the next eight or ten days. The mixture is repeatedly stirred, and fresh additions of the water extract are made from time to time, so as to approximately maintain the original bulk of the contents.

The end has been reached when on taking out the stirring spoon, it is found that the watery fluid runs away from the soap.

Two or three pints of salt are now added, and the boiling continued until a "honey-looking" appearance is noticed. The salt effects the complete separation of the soap from the liquid, with the result that the former, on cooling, forms a crust with the liquid below it.

The next operation consists in cutting the soap crust up into bars.

In practice it is not always possible to hit off the exact quantities of fat and of extract to take. An excess of the former is indicated by the cracking of the resulting soap, a deficiency by its "biting" properties. In the former case the mass is again boiled up with the addition of more extract, while in the latter case it is boiled up again after the addition of salt water.

The Chemistry of the process is something like the following:—

1. The treatment of the ash with water dissolves out the potassium with sodium carbonates.

2. The action of the alkaline carbonates on prolonged boiling is to split the fat into glycerine and fatty acids, which latter, reacting with the alkaline carbonates, form sodium and potassium salts of the fatty acids, viz., soaps.

3. The addition of salt causes the separation of the soap curd from the glycerine-containing liquid, while during the subsequent boiling, some of the potassium soaps are converted into sodium soaps which ensures the end product being a hard soap instead of a possible soft one.

In some cases the method used includes the addition of slaked lime as follows:—

25 lb. of fat.
1 Bucket of ash.
1 Plate of slaked lime.

The ash and slaked lime are boiled with water as in the former process. The soap making in this process, however, takes only about 30 hours' boiling. The explanation is that by the addition of slaked lime to the ash and the subsequent boiling caustic soda and potash are formed, and these are able to "split" the fat much more easily than the carbonates.

To return to the purpose of this paper. At the present time "loog as" is undoubtedly a valuable product; but the main question requiring answer is this: "Is it not possible in normal times to make still more profitable uses of the ash bush than those of soap-making and manuring?"

It would seem to the writer that it should be simple and practicable to obtain almost pure sodium and potassium carbonates from "loog as," or even to transform them into nitrates and cyanides.

The evaporations of the extracts could be carried out largely by the heat obtained on burning the bush itself and other useless vegetation. Besides this, the sun is hot in the Karroo and the air is extremely dry. It would, therefore, appear that the concentration of the extract would prove a simple matter.

So simple does the process appear that it is suggested to chemical manufacturers that the utilization of "loog as" is worthy of their serious consideration.

In conclusion, thanks are tendered for valuable assistance rendered by, and information obtained from Messrs. Thornton, van der Merwe, Lamont, and M. Lundie, of the Government School of Agriculture, Grootfontein, to Mr. Pole Evans, of the Botanical Division, Department of Agriculture, and to Mr. Stahl, Mayor of Middelburg).

Martian Seas.—The Rev. W. F. A. Ellison, in the *Journal of the British Astronomical Association*, directs attention to the significance of the low albedo of the darker parts of Mars. He is of opinion that their albedo cannot be far from zero, and points out that we know nothing capable of so eating up light as to reflect practically none of it except a deep layer of something transparent. He therefore considers the evidence irresistible that the dark areas on Mars consist of deep water.

A NEW SMUT ON *SORGHUM HALEPENSE* NEES.

By Iltyd Buller Pole Evans, M.A., B.Sc., F.L.S.

(*Plate* 19.)

Towards the latter part of February, 1915, Mr. J. M. Sim, of Maritzburg, Natal, sent me for identification a smut on the common Johnson grass (*Sorghum halepense* Nees) of Natal.

On examination the smut proved to be an undescribed species of *Sorosporium,* and I propose to describe it as *Sorosporium Simii* Pole Evans, n.sp.

The description is as follows:—

Sori attacking and destroying the entire inflorescence while still enclosed in the sheathing blade, elongated up to 5-7 cm. long and 1-2 cm. broad, black, becoming powdery, covered at first with a rather thick white or isabelline membrane; spore balls subglobose or ellipsoid, black, 60-150 μ diam.; spores globose or subglobose, olivaceous or olivaceous-brownish, very delicately echinulate, 12-13 μ diam.

On *Andropogon halepensis* Brot., var. *effusus* Stapf., Maritzburg, Natal, February 23rd, 1915.

Sorosporium Simii.—Soris inflorescentiis evolutis easque omnino destruentibus, partim vagina foliari inclusis, elongatis usque ad 5-7 cm. longis et 1-2 cm. latis, atris, pulverulentis, membrana albida vel isabellina crassiuscule primo tectis; glomerulis subglobosis vel ellipsoideis, atris 60-150 μ diam.; sporis globosis vel subglobosis olivaceis vel olivaceo-brunneis, tenuissime echinulatis, 12-13 μ diam.

Hab. in inflorescentia *Andropogonis halepensis* Brot., var. *effusi* Stapf., leg. J. M. Sim, Maritzburg, Natal, February 23rd, 1915.

This grass is now referred to the genus *Sorghum,* and is known botanically as *Sorghum halepense* Nees. It closely resembles the grass known as Soudan grass (*Andropogon sorghum sudanensis* Piper) in habit of growth, in foliage and seed, but is a perennial, whereas Soudan grass is an annual.

Soudan grass, which is a native of Tropical North Africa, has recently been attracting a lot of attention in America and this country as a hay grass, and should it justify its cultivation on a large scale, as it at present gives every promise of doing, the parasites that occur on Johnson grass should be taken into consideration.

The object of this note is therefore to draw attention to the fact that a dangerous smut occurs naturally on Johnson grass in South Africa, and in the opinion of the writer it seems highly probable that this smut may attack Soudan grass unless due precautions are taken.

An opportunity of definitely testing the effect of *Sorosporium Simii* on Soudan grass has not yet arisen, but it is hoped that experiments in this dnrection may be undertaken during the next season.

The mere fact that Johnson grass is a perennial suggests

that infection may not be confined to the seedling plant, but that the fungus may be able to infect the fully-grown plant, as is the case with several other members of the Gramineæ.

Explanation of Plate.

Photograph of three inflorescences of *Andropogon halepensis* Brot., var. *effusus* Stapf., destroyed by smut, *Sorosporium Simii* Pole Evans.

TRANSACTIONS OF SOCIETIES.

Royal Society of South Africa.—Wednesday, April 19th: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Note on Pfaffians connected with the difference-product*": Sir Thomas **Muir.** In addition to the discovery of the connection referred to in the title, a series of theorems was established bringing pfaffians into relation with permanents and other integral functions.—"*Note on the so-called Vahlen relations between the minors of a Matrix*": Sir Thomas **Muir.** The relations in question were critically examined, and an attempt was made to put the subject on a sounder basis. A rectification of the statements hitherto accepted regarding the history of the subject was also incidentally involved.—"*On the development of the Perturbative Function in the Theory of Planetary Motion*": R. T. A. **Innes.** The author had published a paper in the Society's Transactions, 1911, upon the Newcomb operators used in the algebraical development of the elliptic perturbative function. A further extension of the uses of these Newcomb operators was dealt with. At best the development of the perturbative function is very cumbersome.—"*A Contribution to our knowledge of the National Game of Africa*": Dr. P. A. **Wagner.** Among most of the native races of Africa there is played in one form or another, either in rows of holes scooped out of the ground or on wood, stone, or even ivory boards, a peculiar game of skill, which from its wide distribution over the continent has been appropriately styled "the national game of Africa." The game was described by the author, and is essentially a war game. Two players or sides direct a contest between armies of equal strength, the object in view being the capture or "killing" of "men" who are represented by small stones, seeds, shells or fragments of dry cow dung.—"*A Survey of the Scorpion fauna of South Africa*": J. **Hewitt.** The main features of the Scorpion fauna of South Africa have been known for some years, though up to the present no complete lists or descriptions of the fauna as a whole have been available. The author sought to provide a reliable synopsis of the main distinguishing characters of all the species and varieties known to inhabit South Africa.—"*Note on a petiole and portion of the lamina of* Cotyledon orbiculata *functioning as a stem*": Prof. S. **Schönland.** The author described a case of the formation of adventitious roots on a leaf of *Cotyledon orbiculata*, which remained attached to its stem for seven months afterwards. The roots grew considerably, the petiole and the lower part of the leaf thickening and resembling the stem in outward appearance. The petiole retained the external structure of such an organ, and did not turn into a stem, although it had to perform stem-functions for a long time. In analogous cases in other plants, radical changes have been observed.

South African Institute of Electrical Engineers.—Thursday, April 20th: Prof. W. Buchanan, M.I.E.E., President, in the chair.—"*A new system of mine signalling*": R. H. **Gould**. Mine signalling is usually effected by means of trembling bells worked off a D.C. supply. The system described by the author embodies the advantages of the single-stroke bell system, while also preserving the advantages of trembling bells. The connections used underground are identical with those now used for trembling bells: the surface outfit is readily mounted on a switchboard, and there are only two vibrating contacts in the whole system, these being on the surface and easily inspected.

I. B. Pole Evans.—Smut on Sorghum Halepense.

DIE-BACK OF APPLE TREES, CAUSED BY *CYTOSPORA LEUCOSTOMA* (PERS.) SACC.

By Paul Andries van der Byl, M.A., D.Sc., F.L.S.

(*Plates 20-25 and four text figures.*)

Introduction.

Aderhold (**1**) (1903) describes a very destructive disease in cherry trees in the districts along the Rhine as due to *Valsa leucostoma*, Fr. The fungus attacks the larger branches and main stems of the trees, gaining access, in part at least, through the injuries caused by late frosts. From these centres it spreads, causing a one-sided growth of the twig and presenting a cancer-like appearance, accompanied by a copious exudation of gum.

The parasitism of the fungus is definitely established by numerous inoculation experiments, and the relation of the fungus to frosts discussed.

Ellis and Everhart (**2**) record it on peach, plum, and almond trees in Carolina, Pennsylvania, and New Jersey, and state that it probably exists throughout the country where these trees are found. It is also reported as parasitic on stone fruits in Australia (**3**).

Rolfs (**4**) in 1907 contributed to our knowledge of the parasitic nature of the fungus, and showed it to be an active parasite attacking the twigs, limbs, and trunk of peach, plum, apricot and cherry trees. On the peach he found infection to take place at any time during the growing season through wounds, being most noticeable in the spring months. Alternating freezing and warm periods during the late winter months were found favourable to infection. Twigs killed during the winter months at first have a dark purplish skin, which later, on the infected areas, becomes leathery and shades into a scarlet and purple. The leathery, coloured areas finally change to drab, and the skin on diseased tissue becomes loose and wrinkled.

Black fruiting bodies (*Cytospora rubescens* Nitschke) appear on the drab-coloured areas, enlarge and push a white disc-like cap through a transverse slit in the epidermis. During wet weather these black *Cytospora* bodies push out very fine red threads, which are composed of masses of spores. These spores are soon scattered by rain and insects, and start new points of infection.

The diseased portion of the twig soon becomes constricted, making the division between the dead and living tissue very marked. Gum pockets, which rupture the epidermis and produce a copious flow of gum, also frequently form. During the spring and summer months the foliage of infected twigs frequently wilts and takes on a brown, blighted appearance. This effect is produced by the fungus girdling the twigs. A

gradual killing is less frequent. Infections on older branches during the winter months produce oblong wounds extending up and down the stem. The lips of the bark formed over these wounds do not meet, leaving scars, and in very severe cases where there is a constant enlargement about the point of injury rough, black, barrel-shaped enlargements are produced. The disease also causes large cankers and so-called sun-scald wounds on the trunk and larger limbs, and in cases large limbs and even whole trees in different states of vegetation and at different times of the year die suddenly. The foliage of limbs or trees, which die suddenly late in the spring and summer, takes on an unhealthy, starved appearance, and wilts suddenly. The leaves of those that will die in the following winter in most cases also take on a yellowish colour and fall prematurely.

The author also cites a number of inoculation experiments on peach and plum trees, which leads to the conclusion that *Cytospora rubescens* Nitschke is the conidial form of *Valsa leucostoma* Pers. The pustules of these two forms he constantly found intermingled on limbs and trunks, but on the branches only the *Cytospora* form. Inoculations with *Valsa* spores proluced wounds on which developed the *Cytospora* form.

Rolfs (**5**), in a later publication, mentions that the hyphæ of *Cytospora cincta* are usually found associated with a condition in peach trees frequently referred to as winter killing, cankers of the limbs and sun-scald of the limbs and trunk. The perithecial stromata he found abundantly on the limbs and trunks, whereas pycnidial stromata develop freely on the twigs and branches, and also occur on the trunks and larger limbs. Cultures of the fungus were obtained from cultivated cherries, wild cherry, peach and plum trees, and it is claimed that there are sufficient variations to warrant the formation of two distinct varieties, *viz.*, *V. leucostoma cincta* n.var. on cultivated and wild cherry and peach, and *V. leucostoma rubescens* n.var. on the apricot and plum.

Wormald (**6**) describes *Cytospora leucostoma* on young bearing cherry trees at Wye, where in 1910 it caused the death of a large number of trees. Affected trees are described as showing a general yellowing and wilting, commencing at the tips of the shoots. The leaves begin to wither in May, and the whole of the upper part of the tree is dead by October.

Cytospora has been detected on the following fruit trees in South Africa:—

Apple, Maclear, C.P., February 26th, 1912.
Apricot and plum, Swinburne, O.F.S., May 17th, 1912.
Apple, Great Brak River, C.P., November 14th, 1912.
Apple, Pietersburg, Transvaal, February 17th, 1913.
Apple, Muiden, Natal, April 1st, 1914.
Apple, Swinburne, O.F.S., August 8th, 1914.
Peach, Pretoria, Transvaal, March 23rd, 1915.

The genus has thus been reported from all the four Provinces of the Union, but it cannot be said that it has thus far caused a general epidemic. Wherever it is found it is considered a most serious pest, against which little can be done. One farmer said: "This is the most serious disease I have on my farm."

The present investigation was undertaken primarily to investigate further the parasitic nature of the fungus, and to carry out cross-inoculations. The fungus here described was isolated from a diseased apple branch. Recently it has also been isolated from a peach branch, and a comparative study of the two is now in progress. During the season it is hoped to obtain cross-inoculations with fungi from these two hosts, and thus further to study the life-history and parasitism of the genus.

The following appear to be synonyms of *C. leucostoma*:—

Sphæria leucostoma (Pers. Syn., page 39).
Valsa Persoonii (Nits. Pers. Germ., p. 222).*
Valsa leucostoma (Fr. Surnm. Veg. Soc., p. 141).*

The Disease.

Symptoms.—This disease, as observed in apple trees in South Africa, frequently shows at the trunk of the tree near the ground as a coffee-coloured discoloration, and from here spreads upwards. The trees die outright, usually the second summer after they are attacked. On the trunk canker wounds, resembling those caused by *Diplodia pseudodiplodia* Del., are frequently formed.†

Specimens of diseased twigs have also been submitted for examination, and there can be no doubt that as well as attacking the trunks the disease may also start on the branches and spread downwards, this producing a condition which has frequently been observed on peach trees in this country, *viz.*, a die-back of the branches, accompanied by a curling and yellowing of the leaves of infected branches. The skin of diseased branches is decidedly leathery, and in later stages becomes loose and wrinkled. The colour varies from a lightish purple tint to a black purple. The entire dead portions later become dotted over with the black, silvery-capped pustules of the fungus. These pustules form below the epidermis, gradually enlarge, and finally break through a transverse slit in the epidermis, and appear as having a white disc-like cap (Plate 20, *a* and *b*). Dead twigs 14 inches long had these pustules throughout their entire length.

A branch with numerous pustules was placed in distilled water in a moist atmosphere, and soon the spores of the fungus issued out as chocolate-brown curls. Blackish pycnidia breaking through a transverse slit were also observed (Plate 20, *c*).

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* Sacc. **1**, 139.

† "Observations in the Field," by Mr. P. J. Pienaar.

These spores are readily washed away by water, and thus further infection is brought about.

Etiology.—This malady, like so many plant diseases, is caused by a fungus that lives as a parasite on the affected tree. This particular fungus on apple trees is known as *Cytospora leucostoma* (Pers.) Sacc.

The genus *Cytospora* is placed in the group of fungi—"*Fungi Imperfecti*"—the complete life-history of whose members are as yet imperfectly known. For many of the fungi of this group later researches have traced their complete cycle, and the majority of these have been referred to the *Ascomycetes.* The conidia of *Cytospora* are produced in distinct pycnidia, and the genus is thus placed in the "*Sphæropsidiales*" of the "*Fungi Imperfecti.*"

As mentioned in the introduction, Rolfs, by cross-inoculation, has demonstrated that the perfect stage of the *Cytospora infecting stone fruits* belongs to the genus *Valsa* of the Ascomycetes.

The only fruiting body of the fungus noticed on diseased apple trees has been the conidial fructification, and the complete stage failed to develop in cultures in the laboratory. The media on which, and the cultivations under which, cultivated were evidently not suited to the formation of perithecia, which, as far as I am aware, has never yet for this genus been obtained in pure cultures.

Just how this parasite enters the trunks, etc., is not known. Wounds would form favourable places of entrance, particularly on the trunks and thicker branches, and it is not unlikely that infection may also take place through the buds of young shoots. This would explain the dying back of the branches.

Conditions favouring the development of this disease have not thus far been studied. As reported by Rolfs, it will probably be found that trees growing in unhealthy surroundings or subjected to frequent extreme climatic conditions, or trees with an unhealthy root-system will be particularly liable to infection.

A section through a diseased twig shows the brownish-coloured mycelial strands of the fungus ramifying in the cells of the host (Plates 20 *d*, 21 *a* and Fig. 1). The strands, which are septate and branched, measure between 3.08—6.16μ* across The individual cells are often peculiarly swollen, particularly at the ends, and this leads to the shorter cells being somewhat pear-shaped.

The hyphæ are at times closely attached to the cell-walls, and they are also capable of invading the middle lamellæ of the cells, though this is not always easily made out.

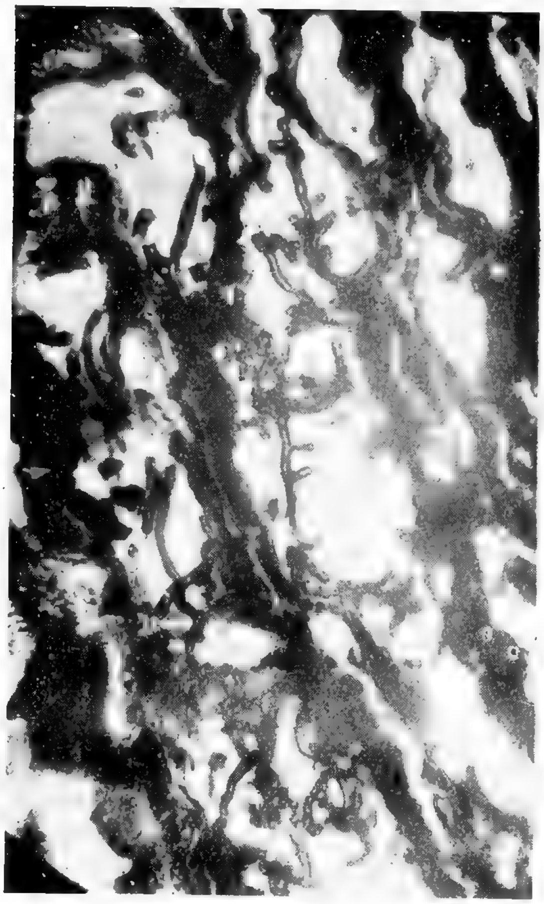
The pycnidia (Pl. 24, *a*) are borne in distinct stromata, which are lens-shaped, subcutaneous, and later erumpent, breaking through with a plane whitish disc. (Pl. 20, *a-b*). The begin-

* A micron (μ) is .001 of a millimetre, or .0004 of an inch.

a

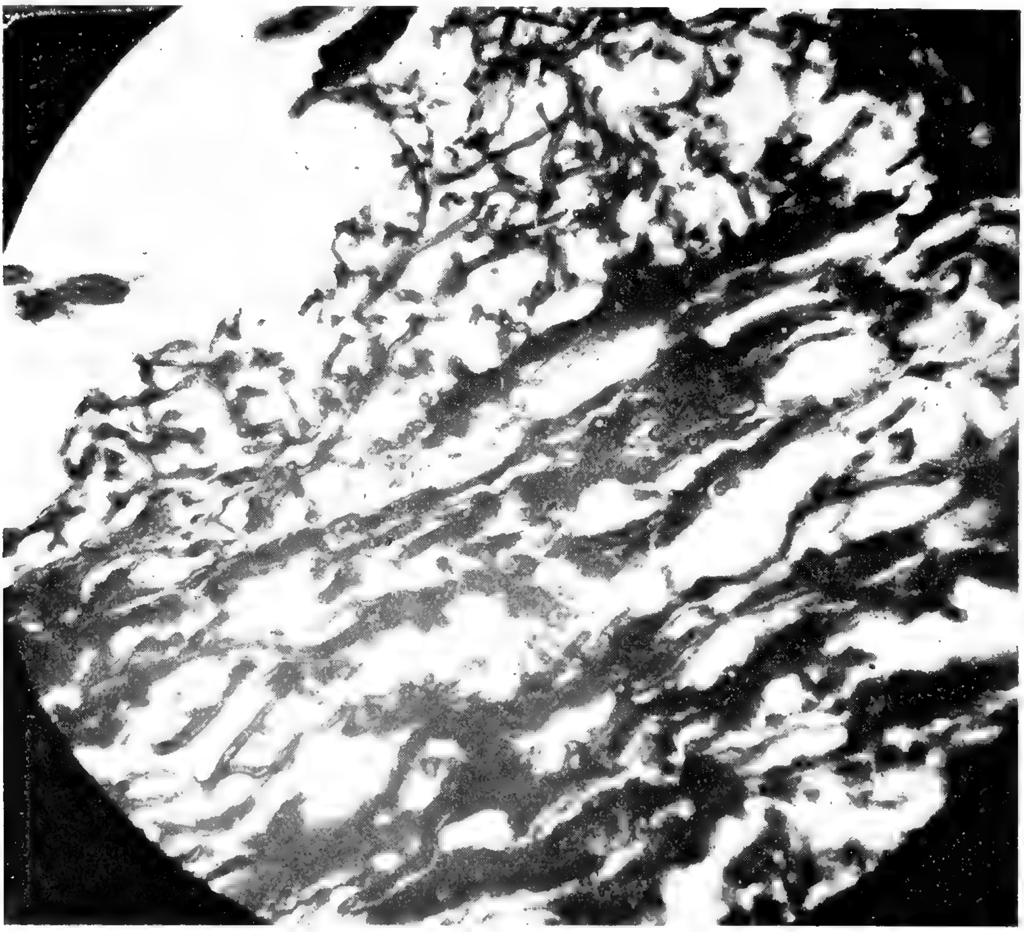
b

c

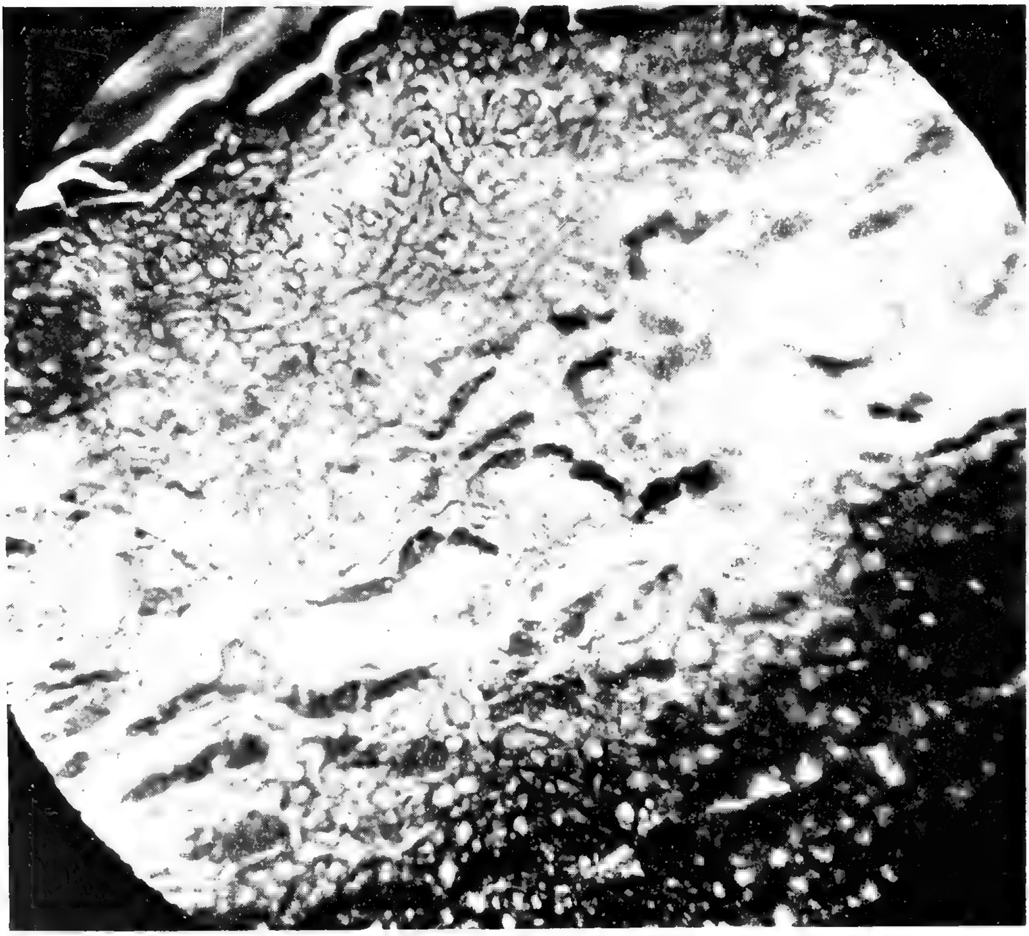


d

P. A. van der Byl.—Die-Back of Apple Trees.



a



b

P. A. van der Byl.—Die Back of Apple Trees.

ning of pycnidia formation in a stroma shews as a dense mass of hyphal tissue (Pl. 21, *b*), in which later the individual pycnidia arise (Pl. 24, *a*). Each pycnidium has its own fairly thick wall (Pl. 22*a*), and contains the spores which are borne on basidia. The basidia are hyaline, biseptate, tapering at the end, and vary greatly in length. The measurements most frequently are 8.24—12.32μ $\times$ 1.131μ.

The spores (Pl. 22, *a*) are hyaline, straight to curved, boat-shaped or allantoid, and with acute or somewhat rounded ends. They measure 4.62—6.16μ $\times$ 1.155μ.

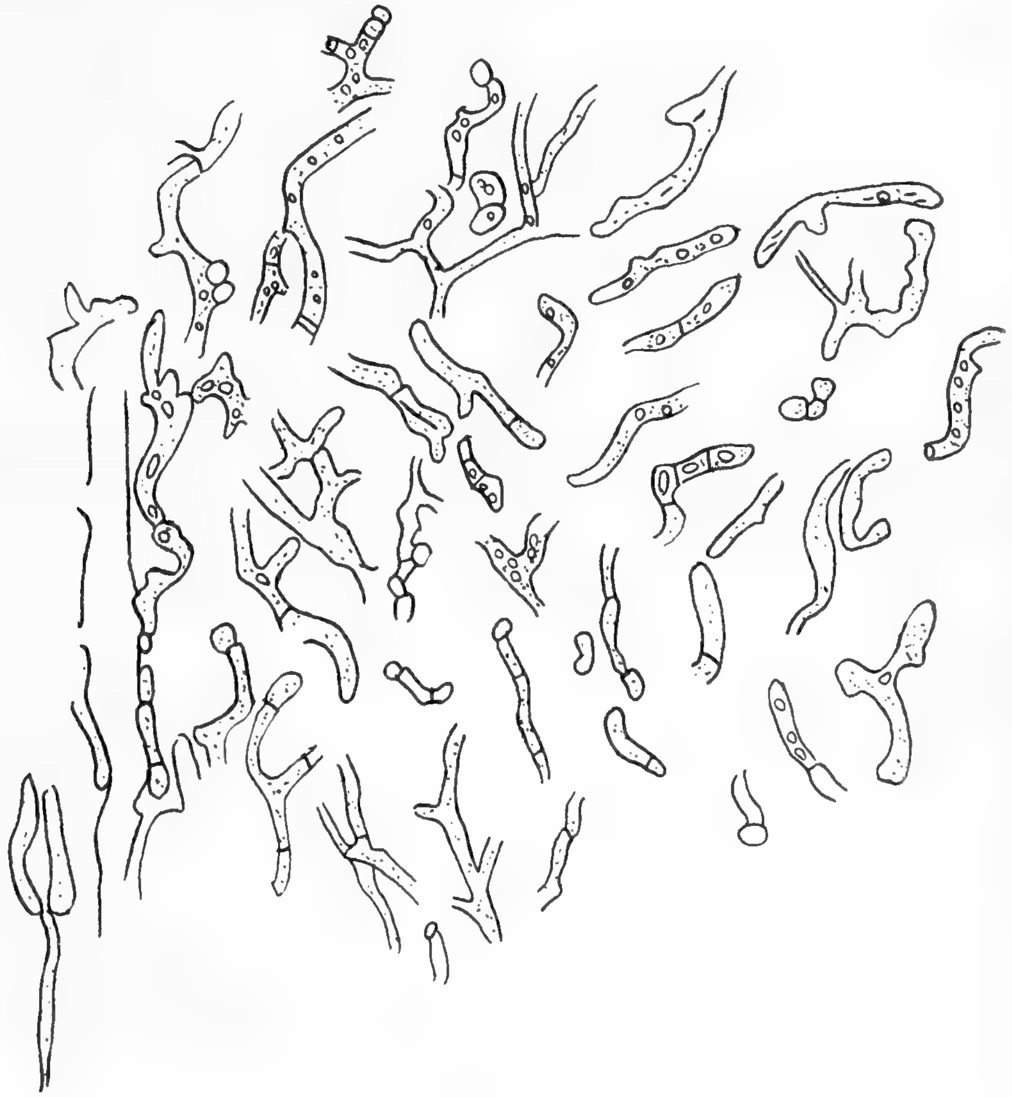


Fig. 1.

The walls separating adjoining pycnidia become confluent, so that the individual pycnidia become united and open through a common stoma (Pl. 24, *a*).

In the stoma peculiarly swollen fungous cells (Pl. 22 *b*) have been observed. These cells are extraordinarily rich in protoplasmic contents, and are multinucleate. The nuclei showed up well with the stain used—Diamant Fuchsin and light green.

These cells evidently belong to the hyphal tissue already referred to from and in which the pycnidia are formed.

Control.

It is doubtful whether spraying already diseased trees with any of the ordinary fungicides will be accompanied by beneficial results, except in so far that it will prevent the further spread of the disease. The only method of effectually combating the disease appears to be the removal and burning of the affected parts.

When only the branches are diseased, these should be well pruned back and immediately burned. Where the malady affects the base of the tree, it is best to uproot and destroy the diseased tree as soon as possible, and thus prevent further infection. Cankers on limbs, etc., should be removed; the wound painted over with some disinfectant, and the formation of the fruiting bodies of the fungus guarded against. Winter applications of lime-sulphur, Bordeaux mixture or copper sulphate, 1 lb. in 25 gallons of water, will reduce the number of twig infections.

Isolation and Growth of the Fungus.

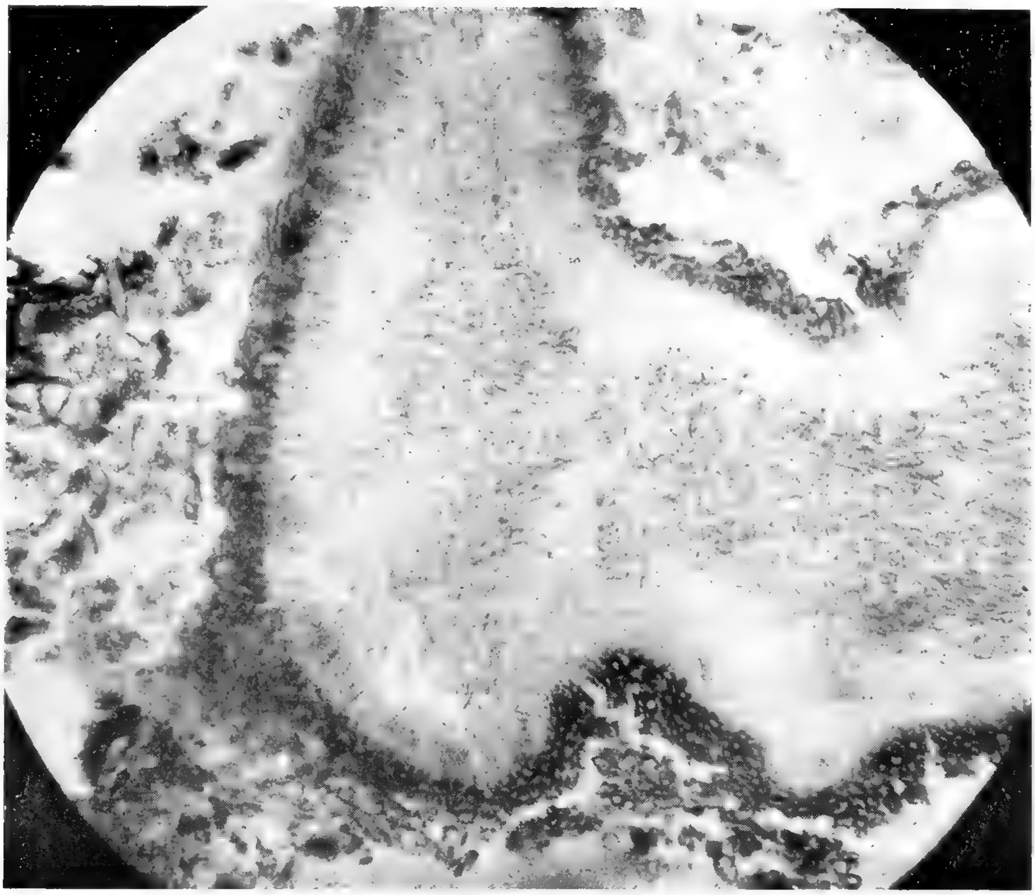
A. Isolation.

The fungus herein described was isolated from apple branches (Herb. No. 3831), submitted by Mr. Petty, Swinburne, Orange Free State. It is interesting in this connection to know that in the year 1912 Mr. Petty submitted specimens of apricot and plum attacked by *Cytospora leucostoma* (Pers.) Sacc.

On the 7th August, 1914, a portion of the apple twig bearing pycnidia was sterilised in Mercuric chloride (1:1000), washed in distilled water, and some of the pycnidia removed with a sterilised knife and crushed on a slide in sterilised distilled water. From this some melted beefbroth agar tubes were inoculated and incubated at 25° C. On the 11th August, 1914, a rich mycelial growth had developed in one of the tubes, and from this were poured beefbroth agar and oatmeal agar plates. By the 20th a blackish growth had formed in the oatmeal-agar plates, and further cultures were made.

After this the fungus was a second time isolated from diseased twigs in a method agreeing well with the above.

Pycnidia of the fungus were first noticed on 19th October, 1914, in an oatmeal agar plate poured on the 31st August, 1914. The medium had entirely dried up, and there were raised hummock-like bodies, often aggregated together, in which were found typical *Cystospora* spores (Pl. 23, *a*). As the fungus was now definitely determined as being the one on the apple twig, it was possible to proceed further.



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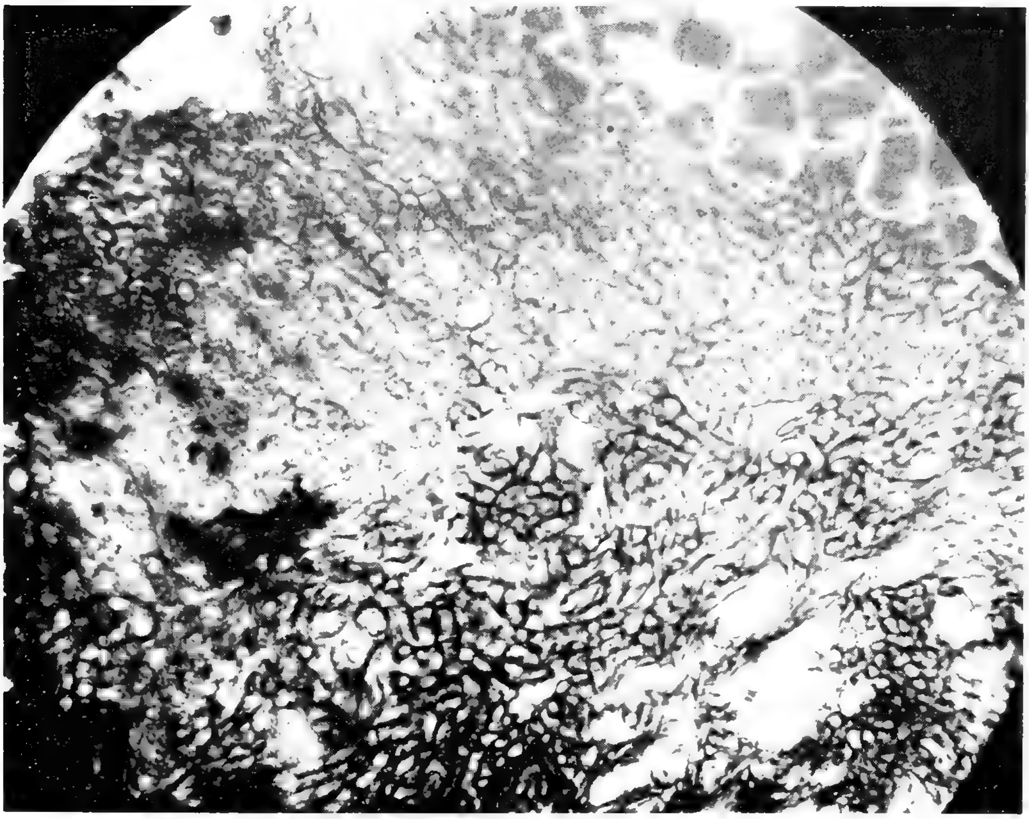
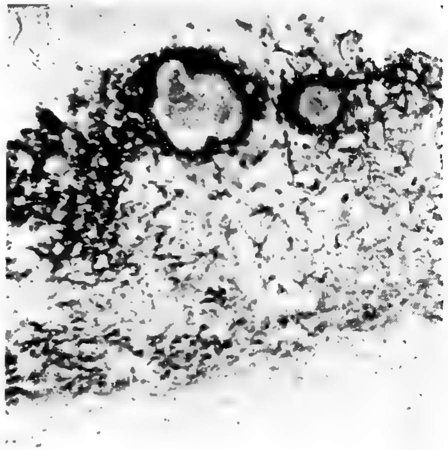


b

P. A. van der Byl.—Die-Back of Apple Trees.



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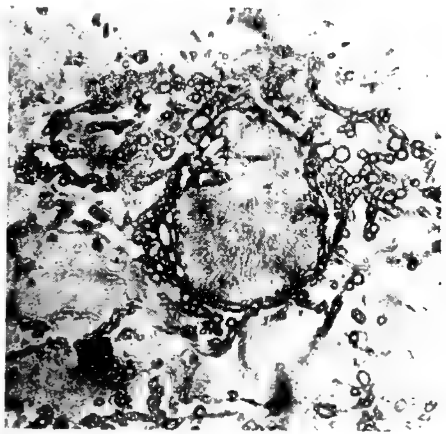

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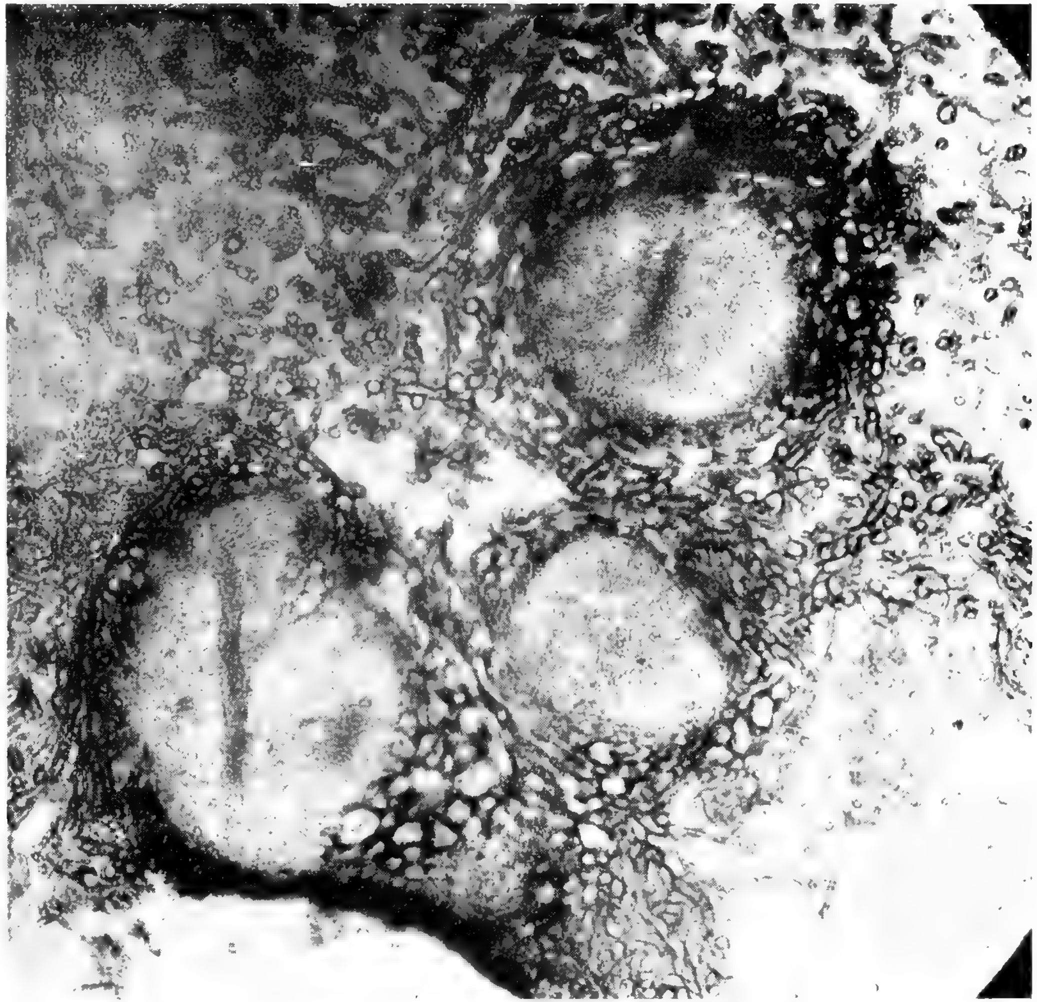


e

P. A. van der Byl.—Die-Back of Apple Trees.

B. Growth on various media.

The fungus grew well on the media tried, with the exception of liquid beefbroth, which does not appear to suit the requirements of the fungus. An ascus stage failed to develop, the media used and the conditions under which grown being probably not suited to their formation.

Potato Plugs (Pl. 23, *b-e*, and Fig. 2).—At 25° C. and 30° C. the fungus within five days forms a delicate pure white somewhat powdery growth. After eleven days the growth, while mostly flat, was of an iron-grey, and covered the whole of the potato. The growth also extended into the cotton wool, which was

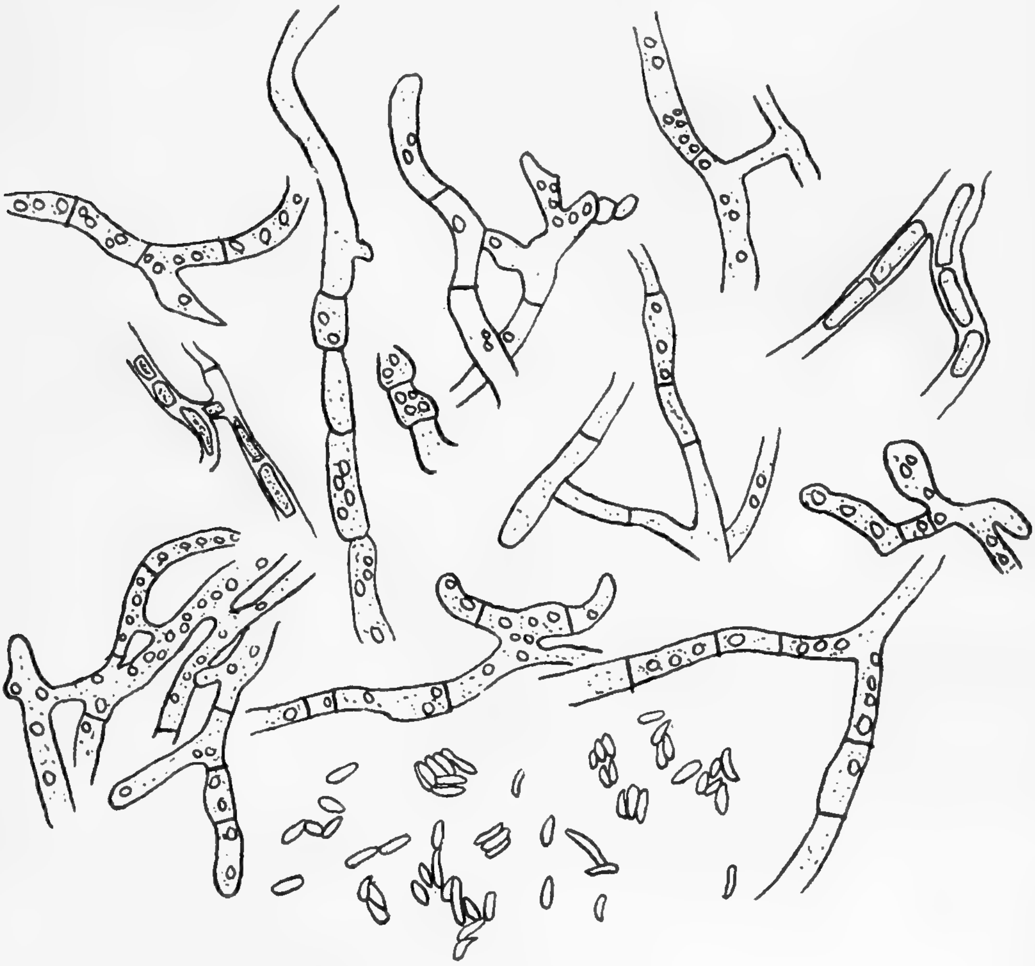


FIG. 2.

coloured madder-brown (Pl. 23, *b*). Where fungus, glass, and medium meet, a madder brown coloration is produced. At 25° C. the fungus within eleven days forms small raised greyish bodies, which are frequently tipped with a "dewdrop." In these bodies are borne the pyncidia, either in a stroma or aggregated together (Pl. 23, *e*), though single pycnidia also occur. At 30° C. within the above time there are numerous black bodies (Pl. 23, *c*), and sectioning shows that the pycnidia here are mostly simple (Pl. 23, *e*); aggregate pycnidia as at 25° C. were not observed.

The mycelium on potato measures 5.95—8.25μ across, and

except for the younger branches, is brown in colour. It is richly branched and closely septate. The individual cells, which are vacuolate, are from 13.2—39.6μ long. Mycelial threads running close together are frequently united by cross-connections (Fig. 2).

The pycnidia, as noted above, are either single or aggregated together. Of the latter, there appears to be two types: (1) The pycnidia, while each having their own wall are enclosed in a common wall, and may thus be said to be borne in a stroma. The walls separating individual pycnidia become confluent, much as occurs normally on the host-plant. (2) The pycnidia, while aggregated together and with thick walls, are not enclosed in a common wall (Pl. 23, *e*). May be this condition is apparent rather than real, and results on the way the sections are cut. The above types are found at 25° C.

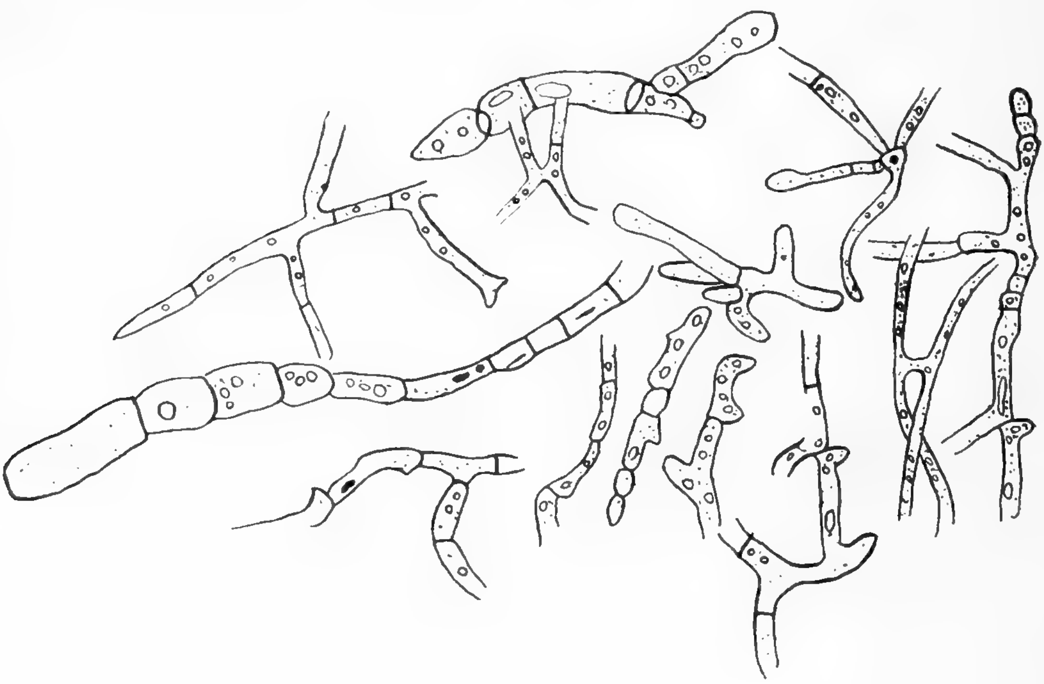
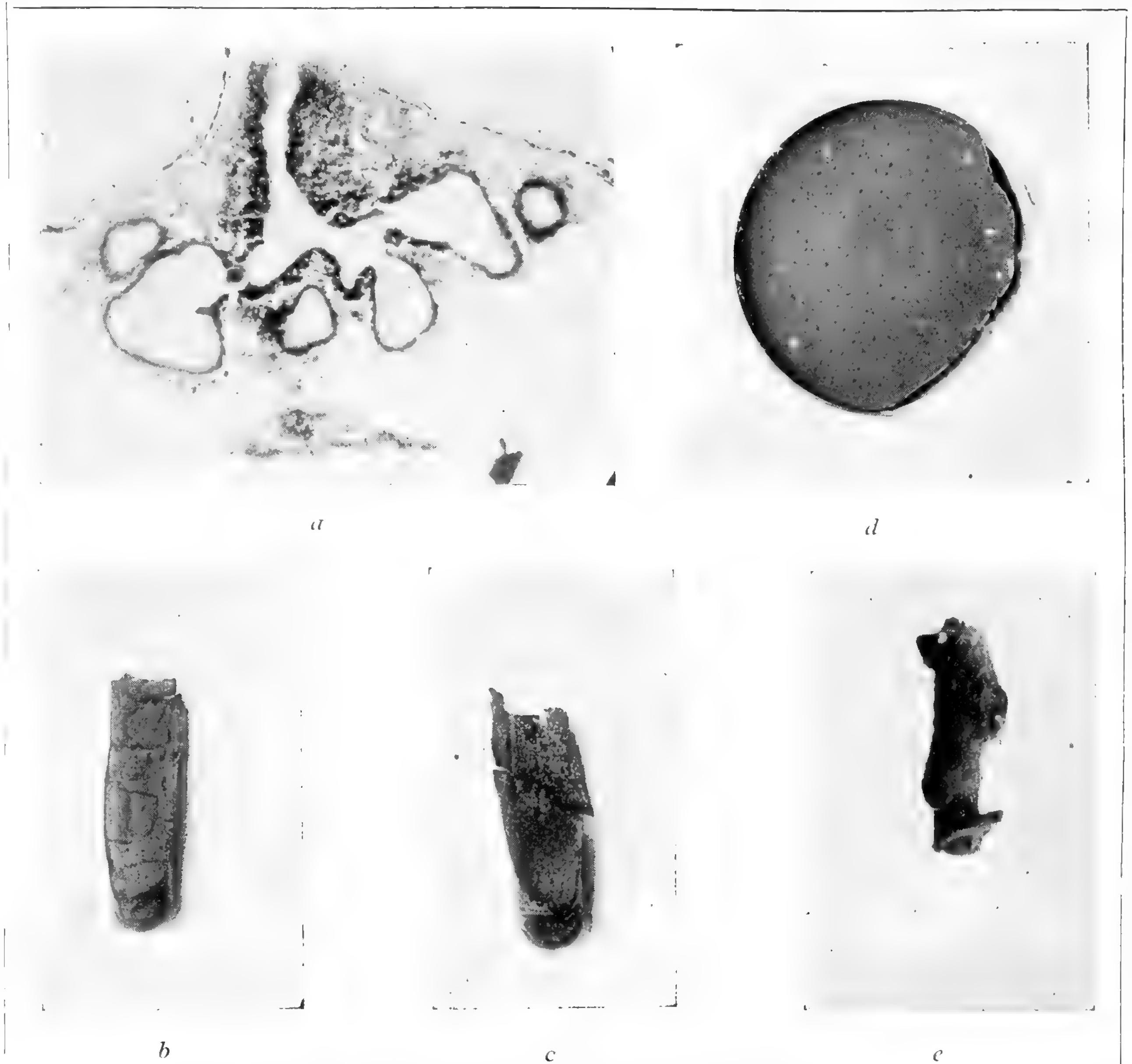


FIG. 3.

At 30° C. the pycnidia appear to be always single, and the walls thin (Pl. 23, *d*). This type also occurs at 25° C. The spores (Fig. 2) are minute, hyaline, allantoid, and measure 4.62—6.16 $\times$ 1.54μ.

Turnip tubes (Fig 3).—At 30° C. the fungus, within five days, formed a vigorous flat, greyish growth, which after eleven days was an ashy grey, and just above the cotton wool and along the glass a madder brown. Where medium fungus and glass met, the colour was of a dark neutral tint. After one month the growth was a mouse colour, with a dark neutral tint above the cotton wool. Cutting the turnip through, it was seen to be dark red all over. Small pustules containing spores were evident on the surface, and raised, hummock-like bodies, containing pycnidia, were also present.



a d b c e

P. A. van der Byl.—Die-Back of Apple Trees.

The cells of the mycelium measure 13.6—33.0μ $\times$ 5.45 — 6.6μ, and are often somewhat swollen (Fig. 3), thus having the general appearance of resting cells. Connections between individual hyphæ (Fig. 3) have also been observed.

The pycnidia, which are abundant, are usually scattered.

Pear Agar slants (Pl. 24, *b*).—After five days, at both 25° C. and 30° C., there was a vigorous, distinctly-raised growth of a violet lilac colour. This growth within 11 days became velvety, and was more of a mouse-grey; in places were the raised, hummock-like bodies containing the pycnidia. Where the fungus extends over the glass, the colour is madder-brown, and where glass, fungus, and medium meet, it is again of a dark neutral tint.

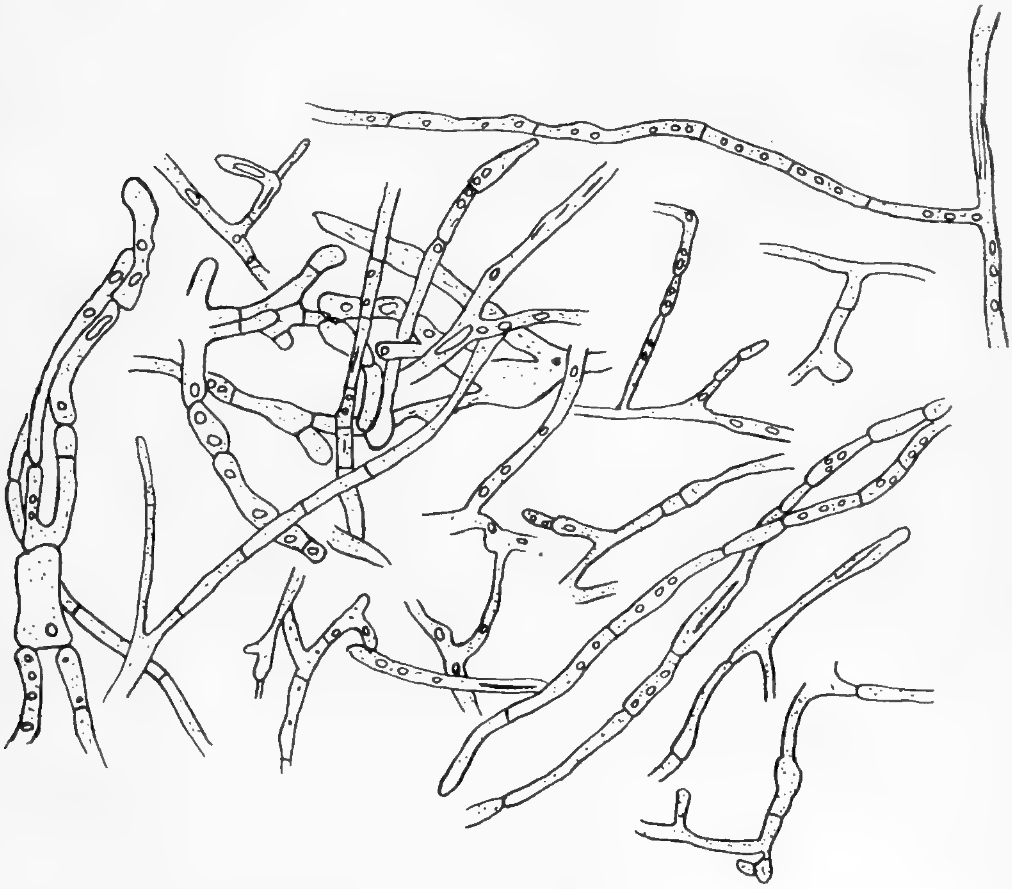


FIG. 4.

The mycelium is most frequently 4.45μ across, and the individual cells from 14.85 — 39.6μ long.

Beerwort Agar slants (Pl. 24, *c*, and Fig. 4).—Within five days, at both 45° C. and 30° C., a vigorous greyish, flat mycelial growth appeared, which within 11 days had become more dense, and varied from light to ashy grey. The colour of the mycelium along the glass, and where the fungus, medium and glass meet, was as in previous cases. After 23 days the ashy growth had become dotted over in places by a lighter grey, which in regions looked as though they might lead to the formation of the hum-

mock bodies. After a month small pustules, with *Cytospora* spores, were observed along the surface, and in places hard, whitish, raised bodies.

The mycelium is often closely septate; the cells, which are usually swollen at the ends, measuring $16.5—33.0\mu \times 5.95 — 6.6\mu$. The cells frequently have a jointed appearance, brought about by the swollen ends. Individually swollen cells, resembling resting cells, have also been observed.

Apple Agar plates (Pl. 24, *d*).—On the 17th September, 1914, plates of the fungus which were incubated at 20° C. and 25° C. were poured. On the 19th there was a good growth at both these temperatures, and on the 24th there were small bodies in the medium resembling fruiting bodies, but in which no spores were found. The plates were not again observed till the 20th November, 1914, by which time the medium had dried up, and raised greyish bodies (whitish in earlier stages) were present. These bodies resemble the hummock bodies already referred to, and contain pycnidia.

Sterilised Peach twigs (Pl. 24, *e*; 25, *a-b*).—Within a month the fungus covers the twig as a mouse-grey mycelial growth. The flap of growth over the water is of a dark, almost black, colour, and where the fungus comes into contact with the glass it is a dark brown. In places are raised whitish to greyish bodies (Pl. 24, *e*), in which again are the pycnidia.

The mycelium, which is richly branched, measures $4.95—13.2\mu$ across. The individual cells are from 6.6—33.0 long, are frequently swollen at the ends, giving the hyphæ a jointed appearance. Cells 19.6μ broad have also been seen, though though not in quantity.

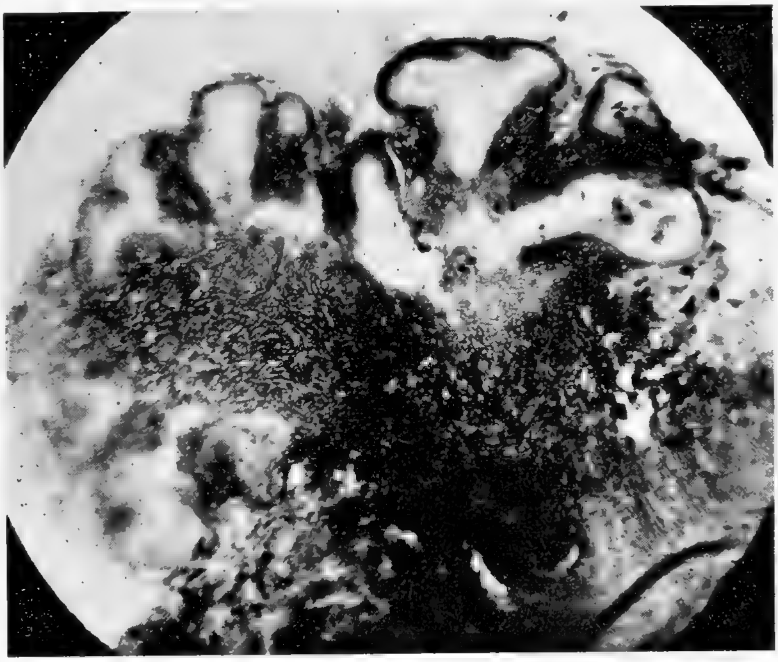
A section through the hummock bodies (Pl. 25, *a-c*) shows them to contain numerous pycnidia. These pycnidia are situated on a dense stroma, and appear frequently in a ring along the upper surface (Pl. 25, *c*) of the hummock body, but also at the sides (Pl. 25 *b*). The walls of pycnidia here, too, have been observed to become confluent, and the pycnidia thus become united (Pl. 25, *a*).

The spores, which are of the typical *Cytospora* type, measure $3.08—4.64\mu + .77—1.155\mu$.

C. Temperature Relations.

Experiments were not specially devised for studying the relation of the fungus to different temperatures, but incidentally, in the course of the work, the conclusion was arrived at that the fungus has a wide range.

Plates of Beerwort agar incubated at 20° C. and 25° C. gave growths about equally strong, and the same result was obtained in tube cultures at 25° C. and 30° C. No growth resulted at 40° C. Growth probably takes place considerably below 20° C., as is evidenced by the fact that, though considerably delayed,



a

b

c

P. A. VAN DER BYL.—DIE-BACK OF APPLE TREES.

it ensued in tubes in an ice-incubator, which, unfortunately, however, was not constant at 0° C.

Summary.

1. The paper describes under the term "Die-back," a disease in apple trees caused by the fungus *Cytospora leucostoma* (Pers.) Sacc.

2. The same fungus has also been reported on peach, plum, and apricot trees, and investigations with the object of learning in how far the fungus isolated from one host is capable of infecting any of the other hosts, and in how far the fungus from different hosts differ in cultural characters, are now in progress.

3. In apple the disease usually shows as a coffee-black colouration near the soil, and from here spreads upwards, but it has also been observed on twigs and branches. Diseased trees usually die the second summer after being attacked, and on the trunks canker wounds frequently result. The skin of diseased branches is decidedly leathery, and later becomes loose and wrinkled. Peach trees which previously looked healthy, have been observed to die suddenly from this disease, and on apricot and plum the malady showed as a dying back of the branches, accompanied by a yellowing of the leaves. The entire dead portion of affected trees later becomes dotted over with the black, silvery-capped pustules of the causal fungus, which then is readily recognisable.

4. Wherever this malady has occurred, it is recognised as a most serious disease, against the spread of which all precautions should be taken.

5. Methods of control should be directed towards the destruction of all diseased parts of infected trees, and further spread of the fungus guarded against by cleansing sprays in the winter.

6. In apple trees the fungus lives in the cells of infected branches, and is also capable of invading the middle lamellæ of the cells. It reproduces itself by minute, hyaline, boat-shaped to allantoid spores, which are borne in pycnidia situated in lens-shaped stromata, which at first are subcutaneous, and later break through with a whitish disc. The spores measure $4.62—6.16\mu \times 1.155\mu$, and the basidia bearing them taper towards the end, and are most frequently $8.24—12.32\mu \times 1.31\mu$.

The mycelium in the host is septate, branched, and the individual cells frequently swollen at the ends.

7. The fungus has been grown in the laboratory on a number of media, and did well. Pycnidia were readily obtained, but the ascus stage has thus far failed to develope.

8. Though the exact relation of the fungus to various temperatures was not determined, it appears to have a wide range. Growth was equally vigorous at 25° C.—30° C., and from a few cultures tried also at 20° C. At 40° C. there was no growth,

and there are reasons for believing that growth takes place considerably below 20° C.

9. The introduction contains references to previous work and the distribution of the malady.

Literature Cited.

1. *Aderhold, A.*—" A Cherry Disease; its Cause and Prevention." Exp. Stn. Records, **15**, 270.
2. *Ellis, J. B., and Everhart, B.M.*—" North American Pyrenomycetes " (1892), 485.
3. *McAlpine, D.*—" Fungous Diseases of Stone Fruit in Australia " (1902), 115.
4. *Rolfe, F. M.*—" Die-Back of Peach Trees (*Valsa leucostoma* Pers.)." Science, N.S. (1907), **26**, 87-89.
5. *Rolfe, F. M.*—" Winter Killing of Twigs, Cankers, and Sunscald of Peach Trees." Expt. Stn. Records, **24**, 450.
6. *Wormald, H.*—" The Cytospora Disease of the Cherry." Exp. Stn. Records, **30**, 352.

Explanation of Illustrations.

The drawings were made with the aid of Edinger's drawing apparatus, with which also the photomicrographs were taken.

Plate 20, *a.*—Photograph showing silvery-capped pustules on apple twig (Herb. No. 8,831).

b.—Pustules on stem of apple tree (Herb. No. 7,734).

c.—Photograph showing blackish pycnidia breaking through in moist atmposphere.

d (× 600).—Photomicrograph. Mycelium in cells of host.

Plate 21, *a* (× 600).—Photomicrograph. Mycelium in cells of host.

b (× 600).—Photomicrograph indicating the dense hyphal mass from and in which the pycnidia are formed. At the bottom is a portion of the stroma.

Plate 22, *a* (× 600).—Photomicrograph of section through pycnidia, and showing the boat-shaped spores.

b (× 600).—Photomicrograph showing the peculiarly swollen cells in the stoma of the stroma.

Plate 23, *a.*—Photomicrograph of section through pycnidia on oatmeal agar; 48 days.

b.—Growth on potato, 14 days, 25° C.

c.—Growth on potato, 11 days, 30° C.

d (× 300). — Photomicrograph. Section through pycnidium on potato at 30° C.

e (× 300) — Photomicrograph. Section through pycnidium on potato at 25° C.

Plate 24, *a.*—Photomicrograph of section through pustule.

b.—Photograph. Growth on Pear agar; 23 days at 30° C.

c.—Photograph. Growth on Beerwort agar; 23 days at 30° C.

d.—Photograph. Growth in Apple agar plate; two months, 25° C.

e.—Photograph. Growth on sterilised peach twig.

Plate 25, *a, b, c*.—Photomicrographs of section through hummock body on sterilised peach twig; one month, 25° C.

Fig. 1 (× 600).—Drawing of mycelium from apple twig.

Fig. 2 (× 600).—Drawing of mycelium and spores from potato culture at 25° C.

Fig. 3 (× 600).—Drawing of mycelium from turnip at 30° C.; 30 days.

Fig. 4 (× 600).—Drawing of mycelium from Beerwort agar slant.

Note.—The illustrations have been reduced in reproduction for the purposes of this paper, and the following allowances must be made for those of which the magnifications are given above:—

Plate 20*d* reduced to ⅔ (= × 400).
Plate 21 *a* and *b* reduced to ⅔ (= × 400).
Plate 22*a* reduced to ⅝ (= × 375).
Plate 22*b* reduced to 4/5 (= × 480).
Plate 23*d* reduced to ½ (= × 150).
Plate 23*e* reduced to 5/6 (= × 250).
Fig. 1 reduced to ⅔ (= × 400).
Fig 2 and 3 reduced to ¾ (= × 450).
Fig 4 reduced to ⅔ (= × 400).

Status of Chemists.—In a circular recently issued in connection with recruiting in Great Britain five classes of men were referred to: (*a*) navvies, tunnellers, and chemists; (*b*) skilled workmen, such as artisans, etc.; (*c*) St. John's Ambulance men, etc.; (*d*) pharmacists and other specialists for the R.A.M.C.; (*e*) men who are not eligible for infantry, but suitable for Departmental Corps, A.S.C., R.A.M.C., etc. It was stated that "men of the classes (*a*) and (*b*) will, if they pass the the necessary trade tests, be finally approved of for their respective corps." Sir William Ramsay thereupon made the following comments in the *Morning Post*:—"It will be noticed that the classes are arranged according to rank, and that chemists are included in the lowest classes. It is charitable to suppose that this has been done in sheer ignorance; but is it not time that men of such gross incapacity as the framer of this leaflet should no longer have any voice in national affairs? This is no isolated instance. My experience has shown me during many years that Government officials, from the Ministers to the subordinates, are disgracefully ignorant, not merely of the nature of the work done by chemists, but also of their professional and social standing."

OSTRICH CHICK DISEASES.

By James Walker, M.R.C.V.S.

(*Abstract.*)

It is only within recent times that ostrich farming attained considerable importance, and for these reasons a study of the diseases affecting the ostrich chick has only lately demanded serious attention.

Different observers have recorded, at various times, diseases affecting the ostrich chick. It is noteworthy that perhaps the more important of these, namely, yellow liver or chick fever, was recorded as far back as 1881 by the late Hon. Arthur Douglas, of Heatherton Towers, C.P., in his book, entitled "Ostrich Farming in South Africa, 1881."

In November, 1911, the writer noted the occurrence of a Leucocytozoon infection in chicks of from three weeks to seven months old, for which the name *Leucocytozoon struthionis* was proposed, for a description of which see second report of the Director of Veterinary Research, October, 1912, page 384. Up till then Leucocytozoa had been found to exist chiefly in wild birds, new species had been described in a few instances in game birds, and less rarely in domesticated birds, and consequently from an economical point of view, its occurrence was not considered of much importance. During the course of investigations in connection with Leucocytozoa infection a number of *post-mortems* were made with the result that, in many cases, chicks showing this affection were also found to be infected with *Strongylus Douglasii* and *Taenia*. The absence of intestinal parasites was, however, noted in some instances, and the cause of death had thus to be disassociated with wireworm and tapeworm infection, and the writer is of opinion that in cases which show an acute infection with symptoms of anæmia, *Leucocytozoon struthionis* is responsible for deaths among young chicks, at any rate when associated with intestinal parasites it may cause a heavy mortality. *Leucocytozoon struthionis* being a blood parasite, its presence can be determined on microscopical examination of blood smears from affected birds.

Although the natural method of transmission has not been determined (transmission experiments with blood of affected birds were negative), it is probable that an intermediate host is the carrier.

In October, 1912, the writer recorded the occurrence of aspergillosis in the ostrich in South Africa,* and later noted this infection in cases of so-called yellow liver or chick fever. With the growth in importance of ostrich farming, the demand for chicks from good feather strains and the rearing of ostriches increased considerably, so much so, that artificial incubation was

* *Trans. Roy. Soc. S. Afr.* **3** (1913), 35-38.

resorted to on a much larger scale than hitherto. Unfortunately, with the increase in production chick fever became more prevalent. For the purpose of noting to what extent aspergillosis existed, a careful examination was made of all chicks sent in for *post-mortem,* and cultures were made from infected and suspected infected tissues, with the result that in a number of cases in which the owner ascribed the cause of death to yellow liver, aspergillus infection was found to be responsible. (*A. fumigatus* being the commoner and more pathogenic species.)

During the course of investigations a number of experiments were made for the purpose of ascertaining the natural methods of infection, with the result that aspergillosis was found to be contracted by chicks from—

(1) Infected straw used in the chicks' sleeping boxes;
(2) From infected incubators;
(3) From infected eggs.

The infection of the incubators was traced to infected eggs.

Aspergillus fumigatus exists frequently in the air chamber of eggs, and was found to be transmitted through the shell from contaminated to clean eggs in the incubators, and dissemination occurs when the shells of infected eggs are broken or opened, *e.g.,* at time of hatching, etc.

The examination of decomposed and unfertile eggs collected from incubators showed that in all cases in which the contents were decomposed, a bacterial infection was found to exist, in some instances in which the contents had no perceptible bad odour, the medium remained sterile.

Aspergillus fumigatus spores were found lodged in the air chamber of some eggs and cultures made from the inner membrane of the shell of others resulted in the growth of a fungus with a sterile mycelium.

It is important to note that the bacteria found in decomposed eggs show considerable motility, and that in many cases the contents were found escaping through the shell wall. The practical importance of these observations lies in the fact that in contact, eggs may become infected and that the bacteria escaping with the contents of decomposed eggs, may infect the incubators.

In young chicks of a few days old the first indication that there is something amiss is a disinclination to feed. When watched closely it will be noted that the chick either picks at the food without taking any in the beak, or lifts some from the ground and allows it to fall. Chick appears dull and weak, eyes half-closed, moves about slowly or stands and frequently utters a plaintive note. The neck is usually flexed and the head lowered and kept close to the body. The abdomen soon loses the tense and full feeling found in healthy chicks, the respiration may or may not be visibly accelerated, in some cases at the later stages, the beak is partly opened from time to time, a long inspiration

being taken; in other instances, the beak was found to be kept continually open. In some cases small whitish nodules, varying in size (averaging size of a pin's head), are to be found on the buccal mucous membrane and other positions in the mouth.

In visibly-affected chicks the temperature was found to be irregular, a characteristic being the marked variations between the morning and evening temperatures 3 to 5 degrees Fahr. (in healthy chicks the rule is to find a difference of about 2 degrees Fahr., 102-104 degrees Fahr.).

Death is usually ushered in with a pronounced fall of temperature.

Death occurs in a few days from the appearance of the symptoms.

It is the exception to find an affected chick recover.

Lesions are chiefly confined to respiratory tracts (lungs and air sacs). It is usual to find on close examination of the lungs at least some nodules, yellowish-white in colour, varying in size that of a pin's head.

The inoculation of potato medium with infected tissues results in a growth of aspergillus within 24 to 48 hours, visible on close examination with the naked eye.

Prevention consists in the use of—

(1) Non-infected incubators;

(2) Non-infected bedding in chicks' sleeping boxes;

(3) Infected eggs should be removed from incubators as well as chicks from infected incubators.

For sterilising purposes boiling water has given satisfactory results.

Observations and experiments have shown that aspergillosis is responsible for the more prevalent of the chick diseases, namely, yellow liver and chick fever.

Acokanthera Venenata.—The last Report of the Director of Veterinary Research, Pretoria, contains an account of an investigation of the physiological action of *Acokanthera venenata* Don, undertaken by Dr. J. H. Burn, of the Wellcome Laboratories, for the Imperial Institute. The experiments were made with a solution of the bitter principle corresponding to a 1 per cent. infusion of the plant in water. Half a milligramme of the bitter substance (corresponding to half a gramme of the plant) was found to be the minimum lethal dose for a 25 gramme frog. For a 300 gramme guinea-pig the minimal lethal dose was 3 milligrammes of the bitter substance, and the cause of death in such a case was paralysis of the respiratory centre. Only with much higher doses was the heart found to be tightly systolic. The *Acokanthera* bitter principles are extremely like those which occur in digitalis, and this resemblance comes out in full detail when the preparation is examined on the isolated perfused mammalian heart.

THE *KGOMA*, OR INITIATION RITES OF THE BAPEDI OF SEKUKUNILAND.

By Rev. Noel Roberts and C. A. T. Winter.

(*Plate 26 and three text figures.*)

Introduction.*

A great deal has been written about the history and customs of various Bantu tribes, but as far as the writer is aware, no complete or consecutive account of the Initiation rites has been given to the public. This is not to be wondered at, for everything connected with these practices is kept profoundly secret, and none but the initiated are ever allowed to be present at the ceremonies. The men are exceedingly reticent when approached on these matters, and refuse to give any information about them, even after they are converted to Christianity. As a rule they are *afraid,* for the penalties imposed on those who reveal the secrets are dreadful in the extreme, and to this day there is danger of being done to death for doing so. For this reason I have suppressed the names of any Natives who have supplied me with information.

In spite of these difficulties, however, it has been found that, with tact and patience, and the skilful handling of any slight knowledge already possessed, it is possible to gain information, either new, or in confirmation of that received from other sources.

A description of these rites, which forms the basis of the present paper, was taken down in Sepedi direct from the lips of M. S. by Mr. C. A. T. Winter, the son of one of the early missionaries sent out to this country by the Berlin Missionary Society. Mr. Winter was born in the country, and speaks the native language perfectly.

The evidence of M. S. is of unique value, since he held the position of chief *Rabadia* of his tribe before he was converted to Christianity.

Using his account as a basis to work from, further information has been gathered from other sources, chief among whom is a native witch-doctor, a relative of the Paramount Chief.

Whenever possible, we have tried to get independent testimony without asking leading questions. The value of this will be appreciated by anyone who knows the readiness of the natives to answer in the affirmative if they expect the answer "Yes." At the same time, we have tried to guard against errors creeping in through natives trying to throw one off the scent by giving false information. The present paper does not claim to be a complete or perfect account of the ritual, but the information is derived from the best sources available, and it should at least serve as a starting-point for further research. Any criticisms, corrections, or additional information will be gratefully acknowledged if addressed to the Rev. N. Roberts.†

* By Rev. N. Roberts.

† The Vicarage, Orchards, Johannesburg.

In conclusion, I wish to bear record to the excellent work of Mr. C. A. T. Winter. His knowledge of the language and of the native mind has been invaluable, and I cannot adequately express my thanks to him for the trouble he has taken in getting information for me, and for his help in other ways; indeed, without him these notes could never have been written. The present writer's work has practically consisted of directing the course of the enquiry amongst the natives, revision, and rendering into English—the real credit belongs to Mr. Winter.

The Kgoma.

Every Mopedi boy must submit to circumcision, and perform the other secret rites of the *Kgoma*, or "Native School," as it is popularly called, before he can claim the privileges of manhood, including the right of marriage in the tribe.

These initiation ceremonies are performed periodically, and always commence when the Kaffir-corn ripens, i.e., about March or April. The proceedings are divided into two parts:

1. The *Bodika*, which lasts for about three months; and
2. The *Bogoera*.

The Bodika.*

A month before the opening ceremonies, the young men of the tribe who have already been initiated are sent out by the chief to gather quantities of long, slender rods of *Moretloa*.† These are tied in bundles and buried in the cattle kraal.‡ They are to be used for thrashing the boys, and are said to be toughened by this treatment.

The *Director of Ceremonies*, or Master of the Lodge, is called *Rabadia*. He has absolute control of all the proceedings, and his word is law. Under him are the *Miditi* (Herders). These are youths chosen from the ranks of those who were initiated during the previous "School." They accompany the *Badikana* (Initiates) everywhere, combining the duties of Instructor, Lictor, and Warden.

When the day chosen for opening the Lodge arrives, the Chief and the Men of the kraal gather in secret conclave, and choose one of their number as *Tipane* (Cutter), whose duty it is to perform the operation of circumcision. As soon as he is elected, he is sent out to choose a suitable spot where the operation may conveniently be performed.

In the meanwhile all the *Mashoboro* (uncircumcised) are summoned to the fireplace of the chief. Each boy brings a bundle of firewood as his contribution to the Chief's fire. There they sleep that night.

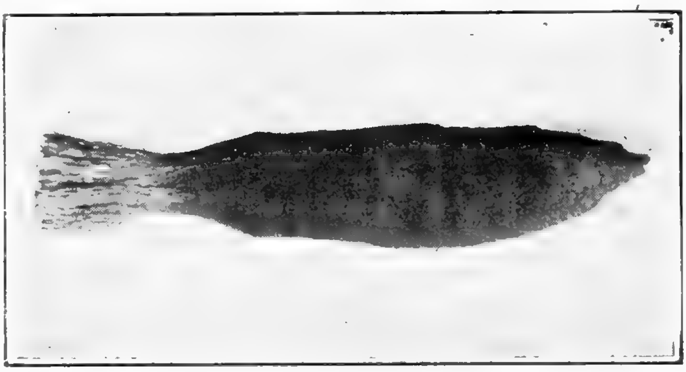
Very early next morning the *Tipane* leaves the kraal secretly, and repairs to the place of circumcision. This is

* *Bodika* = something private; not supposed to be seen.

† *Moretloa* = *Lycium rigidum*. Largely used in basket-making.

‡ See Appendix, Note B.

Dance of Initiates.



Thutsi.

Gari ca Moretloa.

Rev. N. Roberts.—Initiation Rites of the Bapedi.

always situated in the water's edge, in some secluded spot in a ravine. Arriving at his destination, he selects a large flat stone, and placing it in position on the brink of the river, he sits down and awaits the arrival of the *Badikana* and Men.

Soon after the *Tipane* has left the kraal, the Initiates, under the care of the *Miditi,* and accompanied by the Men of the kraal, proceed to the mouth of the kloof. Here the Initiates are placed in a thicket, and surrounded by a guard of *Miditi* and Men.

The Initiate of the highest rank is taken from the rest, and led to the place where the *Tipane* is waiting for him. When he reaches the spot, he is seized and made to stand on the flat stone close to the pool of water; his *stert-riem* is removed, and the operation of circumcision is performed. (See Note A, Appendix.) For the support and protection of the wounded organ a *Gari ea moretloa* (ring of *Moretloa*) is provided for each Initiate. It consists of a wicker ring woven of Moretloa bark and fibre, and is suspended by a string passing round the waist. (See Plate 26.)

The operation over, the Initiate is ordered to "Hold the head" and enter the pool of water. Here he remains, submerged to the neck, while the rest of the boys are brought, one by one, and the same proceedings repeated till all have been circumcised. All this time the Men, and the *Miditi* in charge of those at the head of the kloof, keep up a constant noise by shouting and singing, so that the cries of those undergoing the painful operation are drowned. The boys, therefore, have no idea of what is going to take place before the operation is performed.

When all the boys have been circumcised, the Initiates are called out of the water on to the bank, and the following "psalm" is chanted by the *Miditi*:—

*Kgau Madikana.**

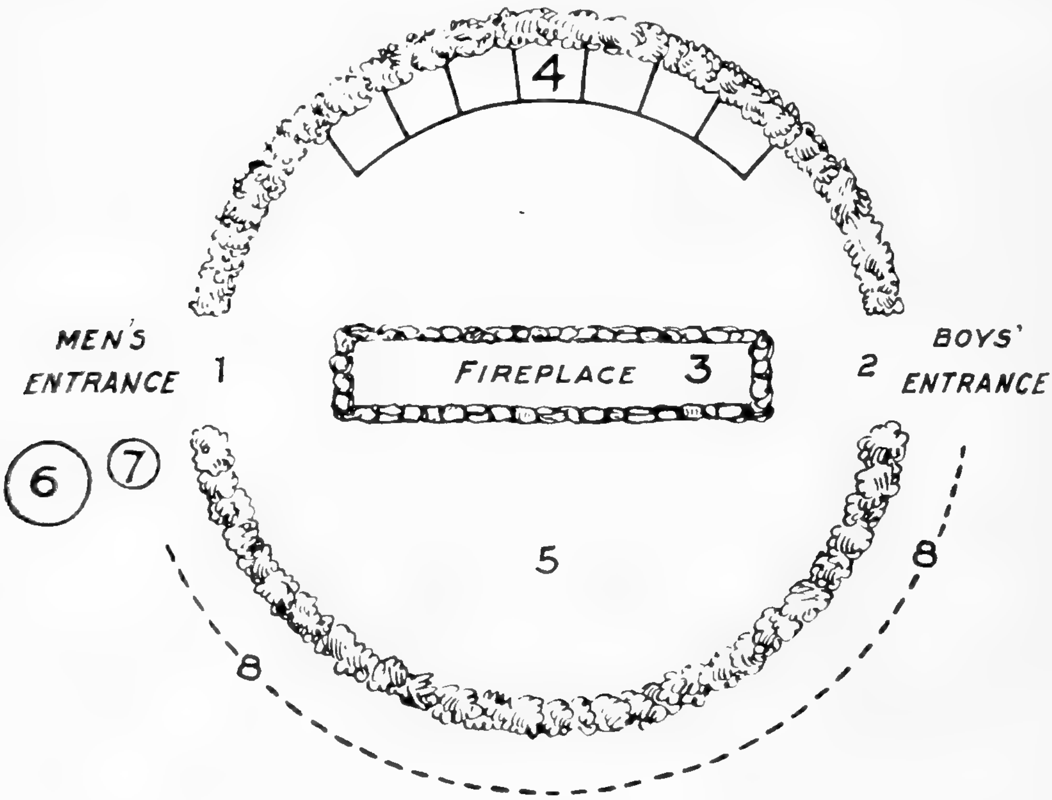
Kgau, Madikana—Follow me, O Initiates.
Madika, le be le—Initiates, Listen.
Le be le nkoago—Listen and hear me.
Lena bana beshu—You our children.
Tshoto maregere—The cartilaginous gland.
Ke sishu sa bo noko—It is only a festering sore of the loins.
Madipa kudupa—....................?

Each line of the psalm is chanted in a monotone till the last syllable is reached, when the voice drops about two tones. All the while the Initiates kneel (before the fire, when sung again later), and accompany the words with a soft humming chorus as follows:—

* The literal translation of this and the succeeding psalms is by Mr. C. A. T. Winter.

At the conclusion of this psalm a party of Men is sent off to build the *Mphato* or Lodge. This takes the form of a circular enclosure with two entrances: one, facing the east, is called the *Khoro ea Banna* (The Gate of the Men); the other, facing the west, is called the *Khoro ea Baloi* (The Demon Gate). The *Khoro ea banna* may only be used by Men who have been fully Initiated in the secret mysteries of the tribe; if one of the Initiates were to enter the *Mphato* by that gate, he would immediately be put to death.

The size of the *Mphato* varies according to the number of the boys to be initiated. It consists of a fence composed of



Plan of the *Mphato* or Lodge.

1. *Khoro ea banna.*
2. *Khoro ea baloi.*
3. The *Tauana.*
4. Sleeping sheds of men.
5. Eating place.
6. *Phiri.*
7. *Pishona.*
8. The *spoor* of the *Phiri.*

branches of trees, which is of sufficient height and density to conceal all that goes on within the enclosure. Sometimes a shed or shelter from rain is erected on the inside for the use of the Men and Herders, but the Initiates have to sleep in the open, around the central fireplace, naked, and without any kind of covering, in all kinds of weather.

When the enclosure has been completed, a long fireplace is built across the centre of the enclosure between the gates. The flame by which this fire is kindled must be produced by the *Leshana*, or "fire drill," and once it has been lit, it is not allowed

to die out again until the close of the ceremonies about three months later.*

When the Initiates are brought to the enclosure, one of their number is chosen as *Mashueu* (lit., " The Shining One ") or Guardian of the sacred flame, and to him is entrusted the task of replenishing the fire, and preserving the flame intact. The sacred fire is called *Tauana* (Little Lion). In order to ensure its preservation the *Mashueu* keeps a stock fire, using logs of *rooi-bos* (one of the Combretaceæ) as fuel. During the day, when the boys are out hunting, the *Mashueu* carries a burning log about with him as a further precaution, and the *Miditi*, always on the watch for any excuse for ill-treating the *Badikana*, keep a sharp eye on him, and give him no opportunity of letting the fire die out.

As soon as the *Mphato* has been completed, the Initiates are brought in, each one bearing a bundle of firewood. One of the most stringent rules is that everybody must enter the *Mphato* before sunset. On their arrival the firewood is stacked, and the psalm *Kgau Madikana* is sung by all who are present. A place by the fireside is then allotted to each Initiate, to be retained till the Lodge is closed.

In the meanwhile, about the time the party is returning to the *Mphato*, all the young girls of the kraal assemble in the space before the Chief's hut, bringing their grinding stones, and grind Kaffir-corn for the use of those taking part in the ceremonies. The meal is then cooked in big pots. Wooden dishes are scrubbed until they are scrupulously clean, and then painted white with *motaga* (lime). When it is cooked, porridge is heaped on each dish, and carried by the girls to a spot some distance from the Lodge. On their arrival they shout " *Rea robega* " (We are heavy), and *Miditi* come out to meet them and relieve them of their burdens.

When the *Miditi* enter the Lodge, they put the dishes of pap on one side. The Initiates are made to kneel in a semicircle, and each *Moditi* washes the hands of the *Modikana* under his care. This ceremonial washing is called *Go tsakatsa*, and is performed with a *thutsi*, or brush, made from the stem of the *Baviaan staart* (Plate 20). The *thutsi* is dipped into a pot of water (*khetlo*), and then the hands of the Initiate are scrubbed with it. When this has been done the *Moditi* says " *Kgoma!* " The Initiate replies by holding out his left hand, fingers and thumbs pointing upwards, and with all the tips close together. He is then struck a sharp blow across the finger tips.

The *Moditi* then says: " *Ke gofe selepe* " (I will give you a hatchet). The Initiate replies by leaning back with his chin up in the air, thus exposing his throat, and another blow is struck across the " Adam's apple."

This ceremony over, they repair to the eating-place, and the *Miditi* serve out porridge with flat slabs of wood. The Initiates

* See this volume, pp. 254, 255, " Bagananoa Rites," Appendix, Note H.

kneel and receive their rations on the outstretched palms of both hands placed side by side, and await the word of command to commence eating. When every boy has been served, the *Miditi* cry "*Hlagaru*" (Eat), and the Initiates stuff the food into their mouths. Sometimes the boys are allowed to help themselves from the bowls, but they may only do so by scooping out the pap with their two hands placed together in the position described above. Sometimes the pap is cooked with milk. In this case it is called *Kgongwana tonana* (Little Bull). While it is being eaten the boys are thrashed with the long *Moretloa* rods afore-mentioned, the *Miditi* crying "*Di kgoma*" all the while. The ceremony is called the *Senana* thrashing. When eating ordinary pap boiled wtih water, the boys are thrashed in the same way, but the cry of "*Seremela*" is used by the *Miditi*. Occasionally as a change in the monotony of the diet, the boys are allowed to toast their porridge at the fire. (See Appendix, Note B.)

After the meal is over the *Miditi* collect the wooden bowls, and with the *thutsi* brushes they scrub off all the whitewash in order to give the women more work and trouble. When asked by the girls what has happened to the dishes, they are told that they have been "Licked by the *Kgoma*," for no blame can be attached to anything done "by the *Kgoma*."

Each Initiate sleeps on the spot apportioned to him by the fireside. On the word of command "*Tsai!*" (Sleep), each boy throws himself down on his back with his legs wide apart, and feet towards the fire, and remains there naked and without covering of any kind, all through the night. The fire is kept up, however, and provides a certain amount of warmth. All are supposed to sleep until they are awakened in the early morning, but frequently the *Miditi*, who seem to be fiends incarnate, devise all manner of cruel tricks to be played upon the defenceless *Badikana*. One of these pranks is to awaken the Initiates secretly, (without the knowledge of the *Rabadia*, who would severely punish the *Miditi* were they to be found out), and to drive them forth out of the enclosure to some deep pool of water, where they are forced to enter the water and completely submerge themselves (*Kgotla*). The moment they rise from the water they are mercilessly beaten across the head and forced to "duck" again. When tired of this, the *Miditi* give the order, "*Tsa ka tsang!*" In obeying this order, the Initiates are forced to wash the wounds left by the circumcision, and to scrape off any scab that may have formed—a most painful proceeding!

Beaten as they are from the time they awake till all are asleep, cruelly knocked about and tortured, the *Badikana* have no spirit of rebellion left in them, and they dare not report the excessive tortures of the *Miditi* to the *Rabadia*.

The Initiates are awakened very early in the morning, and sent forth, guarded by *Miditi*, to fetch water. The water is carried in horns. On their return to the Lodge, they again sing

" The song of the *Kgoma*" (*Kgau madikana*, etc.), which is the signal to the women at the kraal to begin preparing food.

On the days following the day of circumcision, while the wounds are still raw, the Initiates, with their attendant *Miditi*, leave the *Mphato* during the day-time, and hide in some kloof in the neighbourhood where water is to be found. On the previous day the father of each Initiate surreptitiously obtains possession of two pieces of brayed skin, and these are worn by the boys as a covering, before and behind, during the daytime while outside the *Mphato*. A string is passed round the waist, and the skins, one in front and the other behind, are passed through underneath to about the middle, and the upper part is then allowed to drop down. The aprons are thus of double thickness, and are called *Mitjabelo*. The chief Initiate uses aprons of white cloth (*Ngoete*) in place of the brayed skins. These aprons are used only when on the march as a protection from grass or bushes; they are removed when halting, and when the boys return to the *Mphato*, and are rolled up and used as pillows at night.

On reaching their destination in the morning, the Initiates remove their *Mitjabelo*, fold them up, and place them near the spot where their fires will be built later on in the day. This done, the *Miditi* cry "*Hlahla!*" They are then ordered to jump into the water and submerge themselves, and there they are forced to remain a considerable time for the purpose of softening the wound. When the *Miditi* deem fit they order the *Badikana* to come out again, and to remove the scab which has formed. When this has been done they return to the place where they left their aprons. The boys are now divided into small groups; a fire is made in each camp, and sitting round it, the *Miditi* proceed to instruct the *Badikana* in the secret formulæ which are known only to the initiated. These formulæ are generally ancient chants or incantations which have been handed down from generation to generation, and sometimes they are composed for the occasion by the Miditi themselves. The procedure is as follows: A *Moditi* rapidly repeats a line of one of the chants he learned when he was initiated, and the Initiates are expected to repeat the words after him, using the same inflections and tones, accompanied by the same gestures. If the slightest mistake is made the offenders are beaten mercilessly. This is continued till the chant is known absolutely by heart. The *Miditi*, however, take advantage of the fact that the formulæ consist largely of obsolete words, which convey no meaning to the boys, and they therefore invent all kinds of gibberish, choosing the most difficult combinations of words for the purpose of entrapping the boys. This device, of course, produces the desired effect, for the youngsters stumble over the difficulties, and provide their tormentors with endless excuse for their brutal amusement.

The genuine incantations and chants are interesting, and may prove of value in many ways, and we have been fortunate to secure the texts of several. The first one given here is really a

continuation of the *Kgau madikana* already described, and is said to be the most important of them all. They are generally known, as were the Psalms to the monks of old, by their opening words.

No. 1. *MANKIKANA.*

Mankikana! Mankikana!—Traitor! Traitor!

Khuiri mogoapana!—The little biltong* has disappeared.

Pudi e lla mogain—A little goat is bleating in among the thorns of the Haakdoorn.

Ella moa o bitsha modishi—He is crying to call the herder.

E re: Modishi nkgoli—He says: Herder come and pull me out.

Modishi ore: Nka go golla ke le kae?—The herder says: How can I pull you out when I am as I am.

Ke tshaba digooe tsha migaia—I am afraid of the branches of the thorn trees.

Digooe tsha migaia di kgona ke bo tau—These branches are only negotiated by the lions.

Na bonkone elego dilo tsha di lumi—Or by the leopards, because they are things that bite.

Diletshi khateng ga tsela—Which are lying in ambush between the roads.

Di bona mofiti o fetago—To see every passer by.

O feta le 'mpyana tsha 'bo—He passes with little dogs of theirs.

Thamago le tilo—A speckled white and red, with a mottled brown and black.

Bana ba tiloana—Children of a brown and black bitch.

Esego tsha go tsena fsika—They are not fit to get into the rock.

Tsha tsena tsha nntsha sebata!—They would not enter and drive out the brood. †

Tohlanye! Tohlanye! Backa!—Make a noise! Make a noise! You Traitors.

No. 2. *GOEGOANE!*

(Sung by the *Miditi* while the Badikana wash their wounds in the river.)

Geogoane! Geogoane! nyama di metseng—Little frogs! Little frogs! The flesh in the water.

Ki dithoma mang?—Whom shall I send?‡

Mahudu monyane!—The little tortoise.

Oa setang tang—Who is able to frisk about? (Bob up and down.)

Oa go tsela noka—Who can cross the river?

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* *I.e., præputium.*

† *I.e.,* the brood of the coney.

‡ *I.e.,* to catch them for me.—C.A.T.W.

Kgoere ga le moshe—And when he is on the other side.
Are: tetelego!—He says: A ring.
Thetelego di oloana!—A ring by the little ant-hill.
Ntse go tsenang?—What goes in the ring?
Go tsena monoge—A snake goes in the ring.
Noga ea Mosinini—The Mosinini* snake.
Moreto o teng—There is the stripe.
Nkego oa Motadi—The same as that of the Motadi.†
Tade mahusoane—Of the young Tadi.
Moreto o teng—There is the stripe.
Nkego oa monoge—Like that of the snake.

No. 3. *KGUERI, BITSANYANE.*

Kgueri, Bitsanyane—I say, Bitsanyane.
Tsha megoere ea Tshedi—Of the valley of Tshedi.
Kgueri re sa dutshe—I say, while we are still sitting.
Le methepa ea geshu—With our girls.
Ea tsipa ea tabana—On the iron of a little hill.
Ka koa se re kuto—I heard something knock.
Na batsimanyane—It might have been Bitsanyane.
Mogolo oa rena—Our elder brother.

No. 4. *KATA KAEE MAGOPHENG.*‡

Kata kace magopheng—I walked among the aloes.
Rehloa re itshe too—I remained there quiet.
Re gahlana kgalano—We met at the meeting-place.
Le Modi a Tsoku—With Modi of Tsoku.§
Modi oa Tsoku se nkgate—Modi of Tsoku, don't trample on me.
Oa mpona ke betla—Don't trample on me.
Ke betla kga melo—You see me that I am carving a bucket.
Kga melo ea di tshoeni—The bucket of the baboon.
Tshoeni Puleng di a raga—The baboon in the rain always kicks.
Thata go raga sethio dynana—Especially the little heifer.
Malekgele la di tshoene—The precipices of the baboon.

No. 5. *SEDUMO!*

Sedumo! Sedumo!—The thundering roar! The thundering roar!

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* *Mosinini* = a harmless species of snake, with white stripes down the back.

† *Motadi* = a species of mouse, probably *Arvicanthis pumilio*. [N.R.]

‡ According to a Malaboch authority, this is chanted when anybody appoaches the boys "in retreat."

§ *Modi a Tsoku*. *Modi* = a long grass rope stretched across a field, and supported by forked poles, and from which tins, rags, etc., are suspended. When this rope is pulled, these tins, etc, move. It is used for scaring away birds from the crops. *Tsoku* = red ochre.

Sa Ntloa mahura!—Of the Ntloa mahura..*
Ba godi hasona—They who catch them.
Ra gola ra tsha tsha—We catch them and grease.
Ra tsha tsha le naka—And grease the horn.
Naka la morolo—The horn of the kudu.
La morolo tona—Of a kudu bull.
Tholo ga dileme—Kudus do not know how to curve.†
Di no tlatlaretsha—They only mix them up.
Di etshe leshilo—They do it like a fool.
La noka tshe kgolo—Of the big river
Odi le otshana—The Vaal and the Little Vaal.
Bana ba mosadi—The children of one woman.

When lesson time is over, the *Miditi* give the order to dress. The *Badikana* then assume their *Mitjabelo* (aprons). This done, the *Miditi* strike the boys across the throat with sticks in order to "break" their voices (or, as they express it. "to give them men's voices")! The Initiates are then ordered to point out the *Moroka pula* (= Rain maker, the honour name given to the *Rabadia*).

The next order is "*Geu! Geu!*" This means that the party is to spread out in two sections, one to the right, the other to the left, after the well-known manner of a Zulu impi, those leading the left wing bearing gradually to the right, those in front of the right wing bearing to the left, until the leaders meet, thus forming a complete circle. When this is effected they all act as beaters, driving the game which has been surrounded before them towards the centre. In this way they kill quite a number of hares and small game. If any animal escapes, the *Badikana* at that point in the ring where it broke through are severely punished.

Sometimes a coney hunt is organised. Their method is to send dogs into the holes and crevices in the rocks and drive them out; or else they use long pointed sticks, by means of which they probe their hiding-places until they feel the "give," or the movement of an animal, when they rapidly twist the stick, pressing it against the unfortunate little creature, thus gaining a grip on the skin, enabling them to pull it out. The skins of coneys obtained during these hunts are the special perquisite of the Chief, and are carefully collected and stored. They are used for making karosses.

As long as the Initiation rites last the *Badikana* are not allowed to use their ordinary names. Thus, if they address one another, or if called by one of the *Moditi*, the form used would be "*Ele bya!*" (Is it the witch?), and the acknowledgment would be: "*Ele byona!*" (It is the witch). Another way of attracting attention is by whistling.

After hunting in the afternoon, the *Badikana* and *Miditi*

* *Ntloa mahura* = a species of termite or flying ant.
† *I.e.*, their horns.

return in a body to the *Mphato*, which they must enter before sunset. The order of events is followed day after day until the wounds caused by circumcision are healed.

Sometimes the Paramount Chief will visit a Lodge for the *Kgoma* dance. When he enters the enclosure the *Badikana* prostrate themselves, kneeling with faces to the ground, and clap the palms of their hands together above their heads, remaining in this position for a considerable time. If another chief enters the Lodge he is greeted in the same way, but the posture is not maintained for the same length of time. Visitors not of chiefly rank are greeted by the Initiates by clapping of hands only.

When the wounds of circumcision have completely healed, the Lodge prepares for the *Phiri*,* or "*Ashes*" *ceremony*.

A large flat rock is selected, and upon this a huge fire of brush-wood is built. When the rock has become thoroughly heated, water is poured upon it,† and the rock cracks and splits up into numberless small slabs. As the noise of the explosions is heard the *Miditi* cry "*O-hoo-oo-oo!*" beat the Initiates and say: "There! Do you hear the hyæna?" On the first day that this is done the *Miditi* choose out small slabs of stone, not more than eighteen inches across and about an inch in thickness, and grind the edges and polish them by rubbing them against other stones, showing the *Badikana* exactly how to perform the operation. When the slab is perfectly smooth, a wicker covering of *Moretloa* is woven round it as a protection, and for convenience in carrying.

On the following days these proceedings are repeated, but stone slabs have to be selected and prepared by the Initiates only, according to the instructions given them on the first day. When the time for polishing slabs expires, the *Miditi* cry "*Shibe Baloi!*" (Come together, *Baloi*).‡ The whole party then assembles, each Initiate bringing his wicker-covered slab. These are piled up in a heap, and then the *Miditi*, pointing at the stones, belabour the *Madikana* with sticks and cry: "*Ke Phiri e tshueu e tshupya, moroa oa Marokane shlagetshe gae, ea tshea tsenna tsa geshu ea tsebatsebisha!*" (There is the white hyæna, without horns, the son of Marokane § who stole into our Kraal, and carried away our manhood, and danced about with it!)

Then comes the following chant, during the singing of which each Initiate picks up one of the slabs, and the bundle of firewood he has collected during the day, and the party prepares to march back to the *Mphato*.

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* *Phiri* = *Hyæna brunnea*.

† Some of our informants contradict this, and say that it is not necessary to pour cold water on the heated rock, as the heating process itself causes the rock to split into slabs.

‡ *Moloi* = a wizard, *i.e.*, a malevolent magician as distinct from *Ngaka*, a witch doctor. *Moloi* is an opprobrious epithet, but during the *Kgoma* rites it is frequently applied to the Initiates.

§ *Baroka* = name of a tribe near Haenertsburg. (In Sesutho *Maroka* = bad dreams, or dreams about dead people, after which the dreamer must be purified.)

The Song of the Lightning.*

Koa marutsing—In the place where the *Baviaanstaarts* grow.
Ga mogala tladi—Where the brilliant lightning flashes.
Phofolo ea ntshe—The animal of that place.
E tsoala ka koto—Gives birth with the feet.
Bono se la gona—Also it has a "*bono.*"
Ke mahlolodika—That is the miraculous sign.
A mogala tlali—Of the brilliant lightning.

Then follows this chorus:—

Tsoai! Tsoai! Tsoai!—Salt! Salt! Salt!
Tsoai la ntsoetsoenene!—Salt the delicious!
La ntsoetsoenene!—The delicious.

The moment the first words of this chorus are sung the chief *Miditi* take their place in front of the procession, and the rest close in on every side of the *Badikana*, and the homeward march commences. Beating the ground with their sticks, the leading *Miditi* cry, "*Tsoai badikana!*" and the *Badikana* reply "*Mafefu!*"† The *Badikana* are severely handled all the time on the homeward march, being beaten with sticks, and shouldered from side to side. Sometimes the *Miditi* will even cut branches of thorny bushes and throw them on to the heads of the luckless boys. All this cruelty is accompanied by the following chant, sung antiphonally, the versicle being sung by the *Miditi*, the response by the *Badikana*.

The Song of the Salt.

V. *Tsoai Madikana.*—V. Salt, O Initiates.
R. *Mafefu!* R. *Mafefu!*
La ntsoetsoenene—The delicious.
Mafefu. *Mafefu.*
La ga ke dya motho—Which says I do not eat anybody.
Mafefu. *Mafefu.*
Ke dya ea ndyago—I only eat those who eat me.
Mafefu. *Mafefu.*
Eo sa endyego—And he who does not eat me.
Mafefu. *Mafefu.*
Ko shupa ko 'ila—.... ....?
Mafefu. *Mafefu.*
Ko nea ko kgoloane—I am going to give Kgoloane.
Mafefu. *Mafefu.*
Kgoloane Mashala—Kgoloane who always remains.
Mafefu. *Mafefu.*
Mashala ra Noatle—Remains at "Noatle" (?).
Mafefu. *Mafefu.*
Ore go shata byang?—He says: How are you going to remain?
Mafefu. *Mafefu.*

* According to a Malaboch authority this is a *Bogoera* chant, and does not belong to the *Bodika*.
† *Mafefu* is a password, and its use is tabooed to the uncircumcised.

O shale o tsene—Remain and enter.
Mafefu. *Mafefu.*
O tsene ntlong ea sekgolo—Go into the house of the great ones.
Mafefu. *Mafefu.*
Ea sekgolo senu—The great ones of yours.
Mafefu. *Mafefu.*
O letsoale legeu—And cause to give birth to the Geu.
Mafefu. *Mafefu.*
Geu le hubedu—Geu the red.
Mafefu. *Mafefu.*
Le ropa le kebya—With the grey thighs.
Mafefu. *Mafefu.*
Eke le endyago—Who appears to be eating himself.
Mafefu. *Mafefu.*
Dyagoane tena—O you self-eater!
Mafefu. *Mafefu.*
Oa ga ra Sethiane—Of Ra-sethiana.
Mafefu. *Mafefu.*
Namela sethala—Mount the Sethala.*
Mafefu. *Mafefu.*
Ohlaptshe tshona—See if you can see the (trap?).
Mafefu. *Mafefu.*
Tshoma se di bone—I do not see the (trap?).
Mafefu. *Mafefu.*
Ke bona lesiba—I only see the "*Letsiba.*" †
Mafefu. *Mafefu.*
La mo sibegoane—Of the thing which is struck down.
Mafefu. *Mafefu.*
Le sibega puthi—The entrapped duiker.
Mafefu. *Mafefu.*
Puthi ea hlanka—The duiker of the servant.
Mafefu. *Mafefu.*
Ea tshoa ea hlanka—It always goes out as a servant.
Mafefu. *Mafefu.*
Gare ga digoera—In the place newly prepared for cultivation.
Mafefu. *Mafefu.*
Goera tsha mashemo—Of the garden.
Mafefu. *Mafefu.*
Beng ba mashemo—The owner of the garden.
Mafefu. *Mafefu.*
Ba ga rarangoane—That of the father of the assegais.
Mafefu. *Mafefu.*
Ba goga rungoana—They pull out the little spear.
Mafefu. *Mafefu.*
Rungoana la bona—Their own spear.
Mafefu. *Mafefu.*
Ba re: rea siba—They say: We are going to stab.
Mafefu. *Mafefu.*

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* *Sethala* = the elevated platform in the fields.
† *Letsiba* = dropping spear trap (C.A.T.W.).

Ba se siba eona—And they fail to stab it.
Mafefu. *Mafefu.*
Ba siba phathana—They stab a little stick.
Mafefu. *Mafefu.*
Bathan ka pedi—Two little sticks.
Mafefu. *Mafefu.*
Tsha Moshueleshana—Of the little "Rooi-bos."
Mafefu. *Mafefu.*
Na muduhlashana—Or the *Mudhlashana* tree.
Mafefu. *Mafefu.*

During this stage of the *Kgoma* this hymn is always sung when marching away from the *Mphato* and on the return journey. If by any chance they come to a river, they stop singing the chant, and the *Miditi* cry *Taga tsha ka!* (My yellow-fink.) As this finch, a species of *Hyphanthornis,* builds its nest over the water, this exclamation, in the secret or symbolic language of the *Kgoma,* is equivalent to the order, "Cross over the water!" While crossing the stream the Initiates whistle in imitation of the notes of this bird, and when all have crossed, the Song of the Salt is resumed. As they near the *Mphato* they sing *Tsoai,* and return to the Song of the Lightning. This is a signal to the women at the kraal to prepare the evening meal. On arrival at the enclosure the *Miditi* show the boys where to stack their *Phiri* stones.

The above proceedings are repeated every day until sufficient material has been provided for building the *Phiri* and *Pishana** cones. The following day the Initiates are taken out hunting and wood-cutting, in the care of the *Miditi* as usual, but the Men remain behind at the Lodge. When the party is out of sight the Men set to work on these structures. A site is chosen outside the Lodge, close to the Eastern Gate, and a circular hole about 12 inches deep and 30 inches in diameter, is dug for the foundations. The slabs of stone are then removed from their wicker coverings and carefully laid in the form of a disc, the spaces between the stones being filled with ashes. Another layer of slabs and ashes is built upon this, and the process continued, each layer being slightly less in diameter than the lower one, so that a mound, slightly conical in shape, is produced, having a height of from 30 to 36 inches, and with a diameter of about 18 inches below the rim at the top. The uppermost layer of slabs overlaps the edge in such a way as to form a broad circular rim, and is slightly depressed in the centre, so that the apex of the cone is concave. This erection is called the *Phiri,* or Hyæna.

Another cone is then built in the same way, and of the same pattern, but of much smaller size. This is called the *Pishana,* or child of the Hyæna. When the cones are finished, ashes are strewn from the western entrance (*Khoro ea Baloi*) round the outside of the enclosure to the *Phiri.*

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* See Appendix, Note C.

The Initiates always approach the Lodge from the west, and when they arrive in the evening they discover the ashes. The *Miditi* ask them what it means, and being unable to give the correct answer, they are beaten, and told that the ashes are the droppings of the hyæna. The idea conveyed to them is that, just as the droppings of a hyæna outside the kraal are a sign to the inmates that one of those animals has been there in the night, so this is evidence that the mythical or symbolic *Phiri,* of which they have heard mention during the quarrying operations a few days previously, has been there, and if the spoor be followed up the animal may be found. The boys are led one by one along the ash track until they come in sight of the "Cones," and are then told to look upon the sight "with amazement," and asked to explain it. If they cannot do so, they are beaten with *Moretloa* rods and told: *Ke Phiri e tshueu thamaga tsha mabye!* (That is the white hyæna, the spotted one of the stones!).

The *Phiri.*

When the *Mphato* and all traces of the rites are destroyed at the close of the ceremonies, these cones remain standing, the only relic of the *Kgoma.* They are never used again, however, and the name by which they were known during *Kgoma* is changed to *Moruto.*

All the *Badikana* who were initiated at the same time are said to belong to the same *Moruto* or regiment, a name being given to each *Moruto.* Only eight names are used for this purpose, and they are used in succession as follows:—

1. *Masoeni.* (This is the name of the oldest Lodge known.)
2. *Magolopo.*
3. *Matuba.* (This is the *Moruto* to which Sekukuni I belonged.
4. *Manala.*
5. *Makgolo.*
6. *Madikoa.*
7. *Madisa.*
8. *Makgoa.*

The time is now rapidly drawing near when the ordeal will be over, and the *Badikana* will emerge from the Lodge as full-blown men. Before they do so, however, they must cast aside the name of childhood, and assume new names by which they will be known in the future. These names are given in the following way:—For some days the Men (or it may be a single individual) who are most expert in the art of carving remain all day in the *Mphato,* spending their time in carving wooden figures of animals, which are ornamented with poker-work. The most important of these carvings is the figure of a rhinoceros. As the boys sit by the fire in the evening this figure is drawn slowly past them on the ground. As it passes, each Initiate stabs at it with a miniature spear, declaring the honour name which he has adopted. At the same time he is expected to recount the explaits which he is going to perform as a man.

The following oration made by Tlali, a son-in-law of the Chief *Induna* of Sekukuni I, during his initiation is a typical example of what is said on these occasions.

LITHOKO EA TLALI.

"I am the lightning (*Tlali*) of the great kraal of Matsoshie (the Summoner), the relation of Manaka (horns). I am the brave member of a brave stock. I am the pursuer of the human being there at Mamarata maboe. I am the great donga of the river Mathsoane of Molepo. I am the river which took away the grain-bags of the Swazis. The men who rule the country by laying an ambush; the Swazis. I looked into the donga and returned. I found the Matabili a writhing mass. They are called the *Boetsema* of *Mahlaku* of *Makhoro.* I say I will never go to Swaziland again. I declare that having touched the person of a Swazi child, it made my hand stink. They dress in kilts made of arrows. They dress in assegais of spotted colours. The assegais of the black men of *Mogolopo.* The great donga, the son of *Maenche,* of *Molitele.* They say you dress yourself in the chief's dress, though you are not a chief."

When the honour-names have been given to all, the *Madikana* models of other animals are produced. Before this, however, they are privately shown to the *Miditi,* and if they do not recognise the animals, they are beaten. When the figures are produced before the whole company, Men, *Miditi,* and *Badikana* go through the action of stabbing each beast, at the same time repeating its "honour-name."*

The following is a list of the animals represented in this way:—

Rhinoceros, leopard, ostrich, a bird (?), coney, hare, guinea fowl, quagga, elephant, giraffe, baboon, mongoose, tortoise, rooihaas, another bird (?), hedge-hog, lion buffalo, lizard, springbok, ape, ant-bear, waterbuck, centipede.

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* See Appendix, Note D.

The Closing Ceremonies.

The closing ceremony is called *Go aloga,* or The Gathering-up.* The father of each Initiate secretly obtains possession of a *sheep*-skin. These skins are brayed and used for making "*stert-riemen*" and *Hlabes* for the Initiates. The *Hlaba* is a piece of sheep-skin, cut to an oval shape about 12 inches long, coloured red, and worn suspended from the right hip. It is worn by the newly circumcised for some time after their return home. When the skins are brayed they are handed over to the women, who grease them with a composition of red-ochre and fat, after which they are carried by the men to the Lodge at night, and spread upon flat skins stretched upon the ground outside the *Mphato.* The next morning the Initiates are told that they are to go and cut lances, and while so doing they are informed by the *Miditi* that on the morrow they will see their mothers again. The morning following they are taken outside the enclosure, and standing on the outspread skins, the body of each Initiate is smeared with red ochre by some relative. He is then arrayed in "*stert-riem*" and *Hlaba,* and at the same time severely beaten for the last time. A procession is then formed, which marches away from the Lodge to the kraal, singing songs of triumph and victory. Nobody is allowed to look back to the *Mphato.* Each one carries a bundle of wood with which supply the fire at the Chief's kraal. If the party is so fortunate as to have any game to take back to the kraal for the Chief, he will kill an ox in its honour. Ox hides are spread on the ground around the Chief's fireplace, and here they must all sleep at night for a week or more, spending their time eating meat, beer-drinking, dancing, and singing.

The *Rabadia* remains in the *Mphato* when the others leave, and piling up the branches which formed the enclosure of the *Mphato,* he sets fire to them, and so removes all traces of the Lodge, with the exception of the *Phiri* cones.

APPENDIX.

Note A.—"*Gari ea moretloa,*" *substantia nigra tegitur. Quum glandem penem hoc circumdedunt, centrum glandis depressitur. Membranulum præputii tum trahitur ultra finem circi et* "*Tipane*" *præputium projectum secat.*

Note B.—*Ceremonial thrashing.*—Most of the customs of the *Kgoma* are essentially magical rites. The thrashing of the boys may be taken as an illustration.† The custom of burying the *Moretloa* rods in the cattle kraal may possibly be done with the object of imbuing them with magical powers ensuring fertility.‡ The following explanation of the *Sennanna* thrashing was given to Mr. Winter by a native. When the pap is mixed with *milk,*

* *Aloga* = gather up meal which has been spread in the sun to dry.

† *Cf.* Frazer: "The dying god," p. 236.

‡ *Cf.* Frazer: "Golden Bough: The Magic Art," **2**, 317.

the thrashing is not only supposed to teach the boys the duty of caring for their cattle, but also to give them power to win cattle from the enemy. The cry used when *water*-made pap is being eaten shows the reason why they are beaten again. The word *Seremela* signifies the heap of branches and trees gathered together for burning on virgin land which is being cleared for cultivation. The thrashing in this place, therefore, is not only a warning against idleness in cultivating fields, or clearing ground, but may also be regarded as a charm to secure the fertility of the future crops.

NOTE C.—*The* PHIRI *cones.*—It is possible that these structures may be regarded as "*Phalli,*" but in the absence of sufficient evidence it would be unwise to express a definite opinion on the subject at present. Traces of phallism may be found in the customs of practically all the native races of South Africa. The hymns described in this paper, and the symbolic use of *cones* and *rings* in nearly every ceremony, bear eloquent testimony to their phalloid nature. The writer has in his possession a stone *phallus* of perfect form discovered on the site of an ancient cemetery in this country. Similarly the '*Kibi* stone of the *Tzaan* (Bushmen) in all probability represented the female counterpart, used not only as a mechanical aid to the digging stick, but also as a "homœopathic" charm (as Frazer would call it) for ensuring the fertility of the ground or the reproduction of the plants which were dug up.

NOTE D.—The ceremony of naming and stabbing models of various animals is a magical rite for ensuring either:

(*a*) Skill and success in hunting, or

(*b*) Success in war against other tribes. In this case the models of animals represent the tribes of which those animals are *Siboko*. It is noteworthy that no model of the *Porcupine*, which is the totem of the Bapedi of Sekukuni, is included in the list of animals stabbed.*

USE OF BLOOD IN BREAD.—R. Droste advocates in the *Chemiker Zeitung*† that hydrogen peroxide should be used instead of yeast or baking powder when making bread to which blood is added. The blood should be kept in a refrigerator for 24 to 36 hours; the serum is then filtered off and added to the dough.

* See Frazer: "Golden Bough: The Magic Act," **1**, 55; also "Customs of the World," **1**, 148.

† **39** (1915), 634.

THE MINERAL SPRING ON THE FARM RIETFONTEIN, DISTRICT BRANDFORT, O.F.S.

By Prof. MAX MORRIS RINDL, Ing.D.

(*Abstract.*)

This saline spring is situated about two miles from the Haagenstad Salt-pan, and about 30 miles north-west by north of Bloemfontein. Extraordinary therapeutic properties are attributed to the water, and interesting fossils (some described by Dr. Broom in "Annals of the South African Museum," **12**) have been discovered in the spring. The spring issues from a sand-hill capped by a layer of peat, formed from roots of trees, overlying a bed of bones and fossil remains. In order to offer better bathing facilities, the owner has had part of the peat removed, and has erected a primitive bath-house. Through the sand floor of the bath streams of inflammable gas force their way in hundreds of places. This gas consists mainly of a mixture of marsh gas and hydrogen, and can only be a decomposition product of the peat. The mouth of the spring is approximately six inches in diameter, and the daily yield is said to be 600,000 gallons, but this figure is obviously considerably exaggerated. The bath is frequented by hundreds of patients every year, and many wonderful cures are reported. The water is reputed to be particularly efficacious in cases of sciatica and rheumatic complaints. No analysis of the water has, to my knowledge, been published hitherto.

The results of water analyses are usually expressed, more or less arbitrarily, in terms of quantities of different salts per gallon or litre. I have expressed my results in terms of ions, in accordance with the suggestions put forward by von Than and W. Fresenius.

In most cases the values are worked out for water of 4° C. The differences between the values at atmospheric temperature and 4° are as a rule negligible, except in the case of constituents present in tolerably large quantities.

Temperature.—Unfortunately, it was impossible to obtain a sufficient number of observations to establish seasonal variations. The following readings were taken:—

Date.	Temp. of w. ° C.	Date.	Temp. of w. ° C.
29th March, 10 a.m.	28	4th October, 10 a.m.	28.2
29th March, afternoon	29	2nd December, midday	30
30th March, 11 a.m.	29	4th December, early morning	29.5
3rd October, 5 p.m.	29.2	14th December, early morning	29.5

Density.—The density of the spring water at 25° (distilled water 25° = 1) was found to be 1.0015.

Total Solids.—250 c.c. of water of 15.9° were evaporated and dried at 140° C., yielding a residue of 0.5647 grams, so that 100,000 c.c. of water of 4° contain 228.1121 grams of dissolved solid constituents.

Determination of the Anions.

Chlorine.—100 c.c. of water of 20° C. require 36.725 c.c. $\frac{N}{10}$ silver nitrate (mean of two determinations): hence 100,000 c.c. of water of 20° C. contain 130.2269 grams of chlorine, and 100,000 c.c. of water of 4° contain 130.4578 grams of chlorine.

Silica.—For the determination of silica, 3 litres of water were evaporated to dryness; the residue was digested with a little hydrochloric acid, dissolved and filtered. The filtrate was evaporated to dryness, and the above process repeated. The residues, consisting of silica, with a trace of barium sulphate, were dried, ignited, weighed, and treated with hydrofluoric acid. The loss in weight after treatment with hydrofluoric acid represents the weight of the silica. The values obtained from three sets of determinations were as follows:—

1. 100,000 c.c. of water of 4° contain 2.2629 grams of SiO_2.
2. 100,000 c.c. of water of 4° contain 2.0199 grams of SiO_2.
3. 100,000 c.c. of water of 4° contain 2.2746 grams of SiO_2.

Mean value 2.1858 grams SiO_2.

The silica is probably in solution as such. Hence the values are not worked out for $\overset{''}{SiO_3}$ ions.

Sulphuric Acid. ($\overset{''}{SO_4}$).—The filtrates from the above silica determinations were used, and gave a mean value of 0.1766 of a gram, to which is to be added the SO_4 from the barium sulphate precipitated with the silica, namely, 0.0516 of a gram, giving a total of 0.2282 of a gram of SO_4 per 100,000 c.c. water of 4°. water of 4°.

Alkalinity (HCO_3').—100 c.c. of water at 15.9° were neutralised by 1.53 c.c. $\frac{N}{50}$ sulphuric acid (indicator methyl-orange): hence 100 c.c. of water of 15.9° contain 0.001867 of a gram of HCO_3, or 100,000 c.c. of water of 4° contain 1.86889 grams of HCO_3. After the water had been standing for some time the values for the alkalinity were much lower, a portion of the soluble bicarbonates having been precipitated as carbonates.

Nitric Acid (NO_3').—Determined by reduction with zinc-copper couple, distillation, and nesslerisation. It was found that there was 0.00037943 of a gram of NO_3 in a litre of average

temperature 20.7° C., so that 100,000 c.c. of water of 4° C. contain 0.038013 of a gram of NO_3. The amount of nitrate increases very considerably on standing. From water which had been standing for several months values were obtained several times larger than the initial values. Corresponding to the increase in nitrate, a substantial decrease in the amount of ammonia was recorded.

Phosphoric Acid.—The water contains traces of phosphoric acid, obviously from the bones referred to above. A determination of the amount was not made.

Iodine.—The solid residue of three and a half litres was dissolved in the smallest possible quantity of water and poured into alcohol, in order to remove part of the sodium chloride. After distilling off the alcohol, the residue was dissolved in water, and a little chloroform, as well as a few drops of "nitrose," added. The layer of chloroform showed a just perceptible violet tinge.

DETERMINATIONS OF THE KATIONS.

Calcium.—The calcium was determined volumetrically by precipitating with an excess of oxalic acid, dissolving the calcium oxalate in acid, and titrating; and also by determining the excess of oxalic acid in the liquid filtered off from the precipitate of calcium oxalate.

1. On titrating the excess of oxalic acid in the filtrate, 300 c.c. of water were found to contain 0.0274416 of a gram of calcium. 100,000 c.c. of water of 4° therefore contain 9.1686 grams of calcium.

2. Titration of oxalic acid in the dissolved calcium oxalate showed that 300 c.c. of water of 22.5° contain 0.027923 of a gram of calcium; hence 100,000 c.c. of 4° contain 9.3292 grams of calcium.

3. By adding oxalic acid and titrating the excess in the filtrate, the calcium in 100 c.c. of water was found to be completely precipitated by 4.70 c.c. of $\frac{N}{10}$ oxalic acid. Therefore 100,000 c.c. of water of 4° contain 9.5183 grams of calcium.

4. Gravimetric determination: 3 litres of water of 24.3° gave 0.3915 of a gram of calcium; hence 100,000 c.c. of water of 4° contain 9.3533 grams of calcium.

Mean value for the calcium in 100,000 c.c. of water of 4° was therefore 9.34235 grams.

Barium.—Two determinations were made, each in three litres of water, with the following results:—

1. 100,000 c.c. of water 24.3° contain 0.1270 grams $BaSO_4$.
2. 100,000 c.c. of water 21° contain 0.1236 grams $BaSO_4$.

Therefore the mean amount of barium in 100,000 c.c. of water 4° is 0.07374 of a gram.

Magnesium.—After precipitation of calcium as oxalate, the

magnesium in the filtrate was determined as pyrophosphate. Three litres of water gave 0.0109 of a gram of $Mg_2P_2O_7$, so that 100,000 c.c. of water contain 0.0794 of a gram of magnesium.

Iron.—Determined colorimetrically with ammonium thiocyanate. Duplicate determinations were made, on 300 and 696 c.c. respectively of the water. The quantities of iron found per 100,000 c.c. of water were respectively 0.0333 and 0.0335 of a gram, giving a mean value of 0.0334 of a gram of ferrous iron.

Ammonia.—Determined by nesslerising 100 c.c. of water. Two determinations yielded, per 100,000 c.c. of water of 4°, respectively 0.0580 and 0.0598 of a gram of NH_3. Hence the mean value per 100,000 c.c. of water of 4° is 0.0623 of a gram of NH_4'. The amount of ammonia diminishes rapidly, and was found to fall to three-fourths of its original value in less than three weeks. The corresponding increase in the nitrate content has already been referred to.

Aluminium.—Two determinations were made, each on one litre of water; in one case a precipitate of $Al_2O_3 + Fe_2O_3$ was obtained, weighing 0.0064 of a gram. Therefore 100,000 c.c. of 4° contain 0.21380 of a gram of $Al_2O_3 + Fe_2O_3$, of which 0.4775 of a gram is Fe_2O_3, leaving 0.16605 of a gram of Al_2O_3. In the second determination the result was 0.15600 of a gram of Al_2O_3. The mean value is 0.08540 of a gram of aluminium per 100,000 c.c. of water of 4° C.

Lithium.—The lithium was determined by precipitating the calcium as oxalate, removing the magnesium in the filtrate as hydrate, and precipitating the excess of sodium chloride in the solution by means of hydrochloric acid gas. The solution was then evaporated to dryness, and the lithium chloride dissolved out with water-free ether-alcohol. The lithium chloride was converted into the sulphate and weighed as such.

Three litres of water of 20° gave 0.01631 of a gram of Li_2SO_4.

100,000 c.c. of water of 4° gave 0.54463 of a gram of Li_2SO_4.

100,000 c.c. of water of 4° contain 0.06927 of a gram of lithium.

Sodium.—The water was evaporated to dryness, insoluble silica filtered off, precipitating iron and aluminium as hydrates, calcium as oxalate, and evaporating the filtrate, containing sodium, magnesium, and lithium, to dryness, with the addition of sulphuric acid. Three litres of water of 21° C gave 6.9258 grams $Na_2SO_4 + MgSO_4 + Li_2SO_4$, corresponding to 231.3183 grams of mixed sulphates, in 100,000 c.c. of 4°, and to 230.3802 grams of sodium sulphate. Hence 100,000 c.c. of water of 4° contain 74.5934 grams of sodium.

An indirect determination was also made from the amount of chlorine (see under sodium chloride in the calculation of results as undissociated molecules.)

100,000 c.c. of water of 4° contain 74.2160 grams of sodium. Mean value, 74.4047 grams of sodium per 100,000 c.c. of water.

Results of Preceding Determinations.

Anions.

	Grams per 100,000 c.c. of water of 4°.
Chlorine	130.4578
Silica (SiO_2)..	2.1858
Bicarbonate (HCO_3')..	1.86889
Sulphuric Acid (SO_4'')	0.2282
Nitric Acid (NO_3')..	0.38013
Phosphoric Acid	Traces
Iodine	Minute traces

Kations.

Sodium	74.4047
Calcium..	9.34235
Aluminium	0.08540
Magnesium	0.0794
Barium	0.07374
Lithium	0.06927
Ammonium (NH_4')	0.0623
Iron (Ferrous)	0.0334

Calculations of the Relative Numbers of Ions.

Anions.

100,000 c.c. of water contain—

	Grams.	Sum of atomic weights.		Valency		Monovalent ions.
Cl'	130.4578	: 35.46	= 3.67901	× 1	=	3.67901
HCO_3' ...	1.86889	: 61.008	= 0.03063	× 1	=	0.03063
SO_4''.. ...	0.2282	: 98.07	= 0.00233	× 2	=	0.00466
NO_3'.. ...	0.038013	: 62.01	= 0.00061	× 1	=	0.00061
	Total of Anions					3.71491

Kations.

100,000 c.c. of water contain—

	Grams.	Sum of atomic weights.		Valency	Monovalent ions.
$\dot{\mathrm{Na}}$	74.4047	: 23	= 3.23499	× 1	= 3.23499
$\ddot{\mathrm{Ca}}$	9.34235	: 40.09	= 0.23303	× 2	= 0.46606
$\dot{\mathrm{Li}}$	0.06927	: 7.00	= 0.00990	× 1	= 0.00990
$\dddot{\mathrm{Al}}$	0.08540	: 27.1	= 0.00315	× 3	= 0.00945
$\ddot{\mathrm{Mg}}$... ...	0.0794	: 24.32	= 0.00326	× 2	= 0.00652
$\dot{\mathrm{NH}_4}$.. ...	0.0623	: 18.042	= 0.00345	× 1	= 0.00345
$\ddot{\mathrm{Fe}}$	0.0334	: 55.85	= 0.00060	× 2	= 0.00120
$\ddot{\mathrm{Ba}}$	0.07374	:137.37	= 0.00054	× 2	= 0.00108
	Total of Kations	... ...	... ...		3.73265

Calculation of the Constituents as Undissociated Molecules.

Bicarbonates.—The water is slightly alkaline, and on exposure forms a precipitate of ferrous and calcium carbonates. The iron and part of the calcium can, therefore, be regarded as being present as bicarbonates. The ammonia might also be calculated as bicarbonate.

100,000 c.c. of water contain 1.86889 gram of HCO_3; 0.0334 of a gram of iron (ferrous) require 0.07297 of a gram of HCO_3 and form 0.10637 of a gram of ferrous bicarbonate, leaving 1.79592 gram HCO_3 for formation of calcium and ammonium bicarbonates. 0.0623 of a gram of NH_4 correspond to 0.21072 of a gram of HCO_3, and forms 0.2730 of a gram of ammonium bicarbonate.

The residual 1.58520 grams of HCO_3 corresponds to 0.5208 of a gram of calcium, and form 2.1060 grams of calcium bicarbonate.

Barium Sulphate.—On evaporating the water to dryness, after removal of the bicarbonates, an insoluble residue, consisting of a mixture of barium sulphate and silica, remains. The barium is therefore regarded as being present as sulphate.

100,000 c.c. of water of 4° contains 0.1256 of a gram of barium sulphate, corresponding to 0.0519 of a gram of SO_4.

Calcium Sulphate.—Total SO_4, 0.2282 of a gram; SO_4 in barium sulphate, 0.0519 of a gram; the remaining 0.1763 of a gram of SO_4 requires 0.07357 of a gram of calcium, and forms and containing 0.23154 of a gram of chlorine.

Aluminium Oxide.—It is customary to calculate the aluminium as oxide.

100,000 c.c. of water contain 0.1010 of a gram of aluminium oxide.

Magnesium Chloride.—The magnesium in mineral waters is usually calculated as sulphate or chloride, sometimes as carbonate. In view of the fact that the total amount of SO_4 is less than would be required by the magnesium alone if regarded as sulphate, the magnesium has been estimated as chloride.

100,000 c.c. of water contain 0.0794 of a gram of magnesium, corresponding to 0.31094 of a gram of magnesium chloride, and contining 0.23154 of a gram of chlorine.

Sodium Nitrate.—0.038013 of a gram of NO_3 requires 0.01410 of a gram of sodium, and forms 0.05211 of a gram of sodium nitrate.

Calcium Chloride.—100,000 c.c. of water contain 9.34235 grams of calcium, of which 0.5208 of a gram is required for the formation of bicarbonate, and 0.07357 for the formation of sulphate. The remaining 8.74798 grams of calcium correspond to 15.47535 grams of chlorine, giving 24.22333 grams of calcium chloride.

Lithium Chloride.—The 0.06927 of a gram of lithium contained in 100,000 c.c. of water form 0.42018 of a gram of lithium chloride, requiring 0.35091 of a gram of chlorine.

Sodium Chloride.—(1) Estimated from the amount of chlorine: Total chlorine, 130.4578 grams, of which are required for the formation of lithium chloride, 0.35091; for the formation of calcium chloride, 15.47535; for the formation of magnesium chloride 0.23154. The remaining 114.4000 grams of chlorine correspond to 74.2019 grams of sodium, and form 188.6019 grams of sodium chloride.

To the weight of sodium found above must be added that present as nitrate, namely, 0.01410 gram, giving a total of 74.2160 grams of sodium.

(2) Calculated from the amount of sodium that has been directly determined—189.5611 grams of sodium chloride. Mean value, 189.0815 grams of sodium chloride per 100,000 c.c. of water.

Dissolved Gases.

Carbon Dioxide.—Determined by adding a measured volume of $\frac{N}{10}$ Barium hydrate solution, and titrating back the excess.

It was found that 208 c.c. of the water required for precipitation of the total carbon dioxide 1.58 c.c. of $\frac{N}{10}$ barium hydrate. 1,000 c.c. of water therefore require 7.60 c.c. of $\frac{N}{10}$

barium hydrate, and 100,000 c.c. of water contain 1.6720 gram of free and combined carbon dioxide.

The combined carbon dioxide can be calculated from the alkalinity-determination.

100,000 c.c. contain 1.86889 grams of HCO_3, *i.e.*, 1.3479 grams of combined carbon dioxide. 100.000 c.c. of the water therefore contain 0.3241 of a gram of free carbon dioxide.

Oxygen.—The oxygen was determined by Winkler's iodometric method. A stoppered bottle was completely filled with water, 2 c.c., pipetted off, and replaced by 1 c.c. of manganous chloride solution, and 1 c.c. of an alkaline potassium iodide solution. A brown precipitate of hydrated manganese dioxide is formed, which dissolves on addition of hydrochloric acid, liberating iodine from the potassium iodide. The iodine is titrated witn sodium thiosulphate.

100,000 c.c. of water were thus found to contain 0.0615 of a gram of oxygen.

The water was collected under a pressure of 661 mm. and registered a temperature of 29°. Under these conditions one litre of distilled water dissolves approximately 4.66 c.c. (reduced to N.T.P.) of oxygen. The weight of oxygen soluble in 100 litres of distilled water, and under a pressure of 661 mm., is 0.67 of a gram, an amount which is considerably in excess of that determined for the spring water.

It appears, therefore, that the water has considerable oxygen-absorbing power. This was consequently determined by titration with alkaline permanganate. In two determinations the amounts of $\frac{N}{10}$ potassium permanganate absorbed by 100 c.c. of water were respectively 3.00 and 3.07 c.c.

Sulphuretted Hydrogen.—In the bath-house there is an oppressive smell, resembling sulphur dioxide. The amount of this gas in the atmosphere, if present at all, must be extremely small, as seven litres of air siphoned through distilled water containing 10 drops (0.29 c.c. of $\frac{N}{100}$ iodine-starch solution, produced no noticeable change in the colour intensity. In view of the alkaline reation of the water it is scarcely likely that the sulphur dioxide will be dissolved as such; moreover qualitative tests for sulphites with strontium chloride, sodium nitroprusside, and zinc sulphate, as well as with gold chloride, gave negative results. It is thought possible that the sulphur dioxide may be derived from sulphuretted hydrogen dissolved in the water, although the latter could not be identified qualitatively by means of an alkaline solution of lead acetate with Rochelle salt. The water, however, discolours iodine solution, and the results are calculated tentatively as sulphuretted hydrogen, although the discolouration of iodine may be due to the reducing power of the

water determined above. It was calculated that 100,000 c.c. of water contain 0.027477 of a gram of sulphuretted hydrogen.

TABLE OF RESULTS IN GRAMS PER 100,000 C.C. OF WATER.

Saline Constituents.	
Sodium chloride	189.0815
Calcium chloride...	24.2233
Silica	2.1858
Calcium bicarbonate	2.1060
Lithium chloride	0.4202
Magnesium chloride	0.3109
Ammonium bicarbonate	0.2730
Calcium sulphate	0.2499
Aluminium oxide	0.1610
Barium sulphate	0.1256
Ferrous bicarbonate	0.1064
Sodium nitrate..	0.0521
Gases.	
Oxygen	0.0615
Carbon dioxide..	0.3241
Sulphuretted hydrogen (?)...	0.0275

SPECTROSCOPIC EXAMINATION OF SOLID RESIDUE.

Spark spectrum in wave lengths.	Nature and intensity of lines.	Element or compound identified.
671	Sharp.	Lithium 670.8.
656.2	Sharp.	Hydrogen (C) 656.3
628-615.5	Bright band: From 615 to D line band is very faint.	Calcium chloride.
609		Lithium 610.3.
589.6 589		Sodium D.
568	Sharp.	Sodium 568.3.
558-551.7	Bright green band.	Calcium chloride.
515.5	Very faint.	Sodium 515.4.
497.8	Faint.	Calcium chloride.
461.5	Faint.	Lithium (?) 460.2.

In addition a large number of evanescent green bands and lines were observed.

The residue from three litres was used. The figures in the third column are taken from a catalogue of spectra. Where no values are given (*e.g.*, calcium chloride) the identification was effected by comparing the spectrum of the salt in the third column with that of the saline residue. No potassium, rubidium, or caesium lines were found in the spectrum, and no precipitate was obtained with platinum chloride from the solid residue of three litres.

Inflammable Gases.

As the mean of four determinations the values 71.5 per cent. marsh gas and 10 per cent. hydrogen (the remainder being nitrogen) were found. Although the results were fairly concordant, these figures should only be regarded as indicating the order of magnitude, the apparatus used not being of a nature to ensure a high degree of accuracy.

No tests for radioactivity were made, but the writer hopes to have the opportunity of investigating that point at a later date

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Organisation of Science.— Some months ago a Conference, convened by the President and Council of the Royal Society, was held in London, for the purpose of organising scientific effort in the United Kingdom. In addition to the Royal Society, the Royal Society of Edinburgh, the Royal Institution, and the British Association, twenty other scientific societies were represented. A resolution was adopted in favour of establishing a Board of Scientific Societies for the purpose of (1) promoting co-operation among those interested in science; (2) supplying means for giving effective expression to scientific opinion on scientific, industrial, and educational matters; (3) taking the necessary steps to promote the application of science to national industry and service; and (4) discussing scientific questions in which international co-operation seems advisable. Sir Ronald Ross thereupon wrote to the *Times* expressing his approval of the strong efforts that were being made to organise scientific affairs, and his doubt whether the learned societies, as at present constituted, are altogether suited to the task. He held that most of the scientific societies are not always constituted in such a manner as to be representative of the bulk of persons engaged in scientific work. Moreover, he said, they were managed by councils that often did little more than endorse the acts of their officers. Sir Ronald therefore advocated placing the business affairs of science, as distinct from the discussion of science, under a separate body, appointed for this express purpose. At a meeting convened six weeks later to discuss the subject of national neglect of science, resolutions were adopted to the effect that the natural sciences should be made an integral part of the educational courses in all the great schools, and should form part of the entrance examination of the Universities of Oxford and Cambridge, as well as of the newer Universities; that the Government should exercise its power to encourage the study of the natural sciences, and so increase the efficiency of public servants by assigning capital importance to the natural sciences in the examinations for the Home and Indian Civil Service, and requiring some knowledge of those sciences of all candidates for admission to Sandhurst; that the matter is urgent, and should at once be taken in hand by the Government; and that appropriate steps be taken to bring these views to the notice of His Majesty's Government.

THE SIMPLIFICATION OF ENGLISH.

By Prof. Arthur Stanley Kidd, M.A.

The many and great changes which English has undergone in its progress from the synthetic to the analytic are so well known that I do not need to deal with them here. I should like, however, to point out that what makes English a language so peculiarly adapted to modern conditions is the fact that its genius has always developed in the general direction of simplification in accidence and syntax, and of Free Trade, as opposed to Protection, in the importation of foreign vocabulary.

Unfortunately, at the present time, owing to the printed book—especially the manifold grammars—and to the uniformity of educational practice, there is a great danger of the old and wholesome progress being absolutely arrested before the goal of simplicity has been reached.

Our schoolmasters and, of course, our Professors seem to have set their whole energy to work to stop any grammatical progress at all. It is something like the old struggle between Classicism and Romanticism. What is natural and simple is thwarted by the sullen ultra-conversatism of certain antiquated rules and laws laid down by grammatical Boileaus—

> " Closely wed
> To musty laws lined out with wretched rule
> And compass vile."

The truth is that we need a Romantic Movement in English grammar.

> " Is there so small a range
> In the present strength of manhood, that the high
> Imagination cannot freely fly
> As she was wont of old?"

Simplification of Grammar.

In some of the newest English grammars I find that there is a tendency to give thousands of examples of errors commonly made by speakers of English. " It is surprising," says one editor (W. T. Webb), " into what simple mistakes even educated people fall, who have not made a definite study of grammar and idiom." Among examples of mistakes he gives the following:—

There are no *less* than fifty cows in the field.
He enquired about *your state of health.*
Where have you been *to?*
Directly he comes, you may go.
Be sure *and* ask him to come.
I like *these sort* of pens.
So far from consenting, he refused point blank.

Surely such well-established uses as these might be accepted even in written composition, and yet Mr. Webb gives many others of the same type as "common errors," including, of course, poor Mrs. Hemans' alleged confusion of two constructions in *Casabianca*—

"The boy stood on the burning deck,
Whence all *but he* had fled."

If anyone were to ask me to make definite proposals for simplification I should refuse to comply without very careful thought. However, there are a few time-worn things which, I think, should be thrown over-board without hesitation; for example, the objection to the *Split Infinitive* (in spite of its occasional ugliness); and the pronoun-form *whom* should be abolished, together with the prejudice against the superlative in such sentences as *this is the best of the two bicycles.*

In spite of the pedantic Gabriel Harveys of the Twentieth Century, then, we should legitimatize the Split Infinitive, and various uses of the relatives should no longer be sneered at as only "natural" sons of the English language. These (*sic*) sort of changes should be made, and as long as neither of the last two are (*sic*) allowed in polite grammatical society, so long will it be impossible for you and I (*sic*) to really feel (*sic*) that the language is progressing.

As regards our old, crotchety acquaintances, Messrs. Will and Shall, with their equally crotchety relations Would and Should, they should be treated with a more generous hospitality, and we should avoid ever making the most of their little differences. By this courtesy we will (*sic*) succeed in bringing Scotland, Ireland, the Dominions, and the Colonies into a grammatical union of hearts, and the Empire will, if we would (*sic*) do this, secure a happy issue out of its linguistic afflictions.

As regards the grammarians who are inventing new errors of speech and composition by the score, I should also like to protest against their refusal to acknowledge the gradual rise of words and phrases in the social scale, from slang and colloquialism to respectability. The grammarians live in the remote past and nevertheless wish to legislate for the present.

Mr. Webb, for example, in his excellent book, "A Guide to the Study of English," says: The following sentences contain colloquialisms (italicised) that should be avoided in writing:—

Charles tried to *back out of* (withdraw from) his engagement.

The commander had *a bone to pick* (an unpleasant matter to settle) with his officers.

The general was *handicapped* (at a disadvantage, hampered) by his want of cavalry.

Hampden showed plenty of *grit* (spirit, courage).

In this way, it seems to me, our pedants aim at *decœrating* (or making flat) our current style. Fortunately the Americans

are more than counteracting this effort by their—sometimes intemperate—love of champagne in the spoken and written word.

SIMPLIFICATION OF SPELLING.

Another and perhaps a still more important matter is the need for a simplified spelling of English. This is an old subject of debate, and I need not go into the matter at any great length.

Some years ago I received, from the Simplified Spelling Board of America, an avalanche of interesting pamphlets. In these pamphlets the case for reform is put very effectively and very sensibly, and a few pertinent extracts will not be out of place.

(1) "The English language is on the way, as many believe, to become an international language. For this destiny it is peculiarly fitted by its cosmopolitan vocabulary and its grammatic simplicity. It is much easier to learn than any highly inflected language can be, and it has the immense advantage over any invented language that it is the organ of a noble literature and of a civilization already widely diffused in all parts of the earth. There is, however, a widespread and well-grounded conviction, that in its progress our language is hampered by one thing—its disordered and intricate spelling, which makes it a puzzle to the stranger within our gates and a mystery to the stranger beyond the seas. English is easy and infinitly adaptable; its spelling is difficult and cumbersome."

(2) "Some of the novelists—not the most distinguisht, of course—have opposed simplification. Many of the poets—and not a few of the foremost—have advocated it. Tennyson, for one, was an Honorary Vice-President of the English Spelling Reform Association; and Landor was outspoken in his desire to make English spelling more exact as an instrument for literature. Matthew Arnold suggested a commission to review English spelling, pointing out evident anomalies and suggesting possible amendments. M. Faguet cites a number of leaders of French literature who have advocated simplicity of orthography, and who have themselves insisted on the simplification which best conveyed their meaning. Ronsard, for example, advised poets to avoid all superfluous letters and to use them as soberly as possible, 'awaiting a better reformation.' Corneille and La Fontaine, Voltaire and Sainte-Beuve, proclaimed the same doctrin, either by their preaching or by their practis . . . . And Sainte-Beuve declared perfectly vain the contention that needless letters should be kept in a word to reveal its derivation, 'since a letter or two will never help the ignorant to recognise the origin of a word, and the educated will know it anyhow.' (Professor Brander Matthews.)"

(3) Professor Lounsbury writes: "I venture to say that there is not either in this country [America] or in England a

single scholar in English, to whom other scholars would feel that deference is due, who is opposed to this movement in itself. He may, perhaps, think it inexpedient, tho even of such I know none personally. He may think it useless to attack practices so strongly intrencht behind a barrier of ignorant belief and prejudice. But he will not condemn it on the ground of justice or right."

Among the members of the Simplified Spelling Board (in October, 1909) I find, in addition to many distinguished Americans, the following English names:—William Archer, Henry Bradley, F. J. Furnivall, Sir James A. H. Murray, Walter W. Skeat, T. G. Tucker, and Joseph Wright.

Nevertheless, in spite of this consensus of expert opinion, as Professor Lounsbury says, "The superstition as to the sanctity of our spelling is so strongly intrencht behind a barrier of ignorant belief and violent prejudice, and this so fortified by use and wont, that even to carry its outworks will require the time and effort of years of struggle."

In concluding this section of my paper, I should like to point out that, in spite of our countless grammars and pedants, with the single exception of Wordsworth, "there is," according to De Quincey, "not one celebrated author of this day [a century ago] who has written two pages consecutively without some flagrant impropriety in the grammar, or some violation more or less of the vernacular idiom." This is certainly equally true of the century which has elapsed since De Quincey wrote these words, and among the offenders I could name some living Professors of the English Language and Literature in the Universities of the United Kingdom, if their composition be judged by the standard and canons of the pedants. The man who never makes a mistake never makes anything. We need not, however, imitate the conscious carelessness of Byron, of whom one critic says: "We have heard about his slips of grammar till we are tired; they have even been magnified till they almost dwarf his slips of morality."

Simplification of Other Languages.

There are two notable examples of languages in which an attempt at simplification has been made, *viz.*, French and Dutch, so that we have at least two precedents, without troubling about a modern reform in German spelling.

As regards French, at the end of July, 1900, the *Ministre de l'Instruction publique* gave his formal approval to certain licenses (*tolérances*) in spelling and syntax suggested to him by a special Commission of the *Conseil supérieur de l'Instruction publique.*

These licenses are in the direction of simplification, particularly of the elimination of antiquated anomalies, quaint irregularities, and exceptional peculiarities. It is true that they have

not yet won universal acceptance, though they are admitted in French schools and Universities, are enumerated in grammars of every kind, and even recognised by our own University.

Nevertheless they have naturally met with much opposition, and their present position is one of some difficulty.

That ultra-conservative body, the French Academy, has fought hard against some of the *tolérances,* though even it has accepted others. The moral is that any improvements of a language, however necessary or expedient, will have to face the most active opposition of inveterate prejudice.

As regards my second precedent, Dutch, we know that the "Reformed" spelling recommended by the *Vereniging tot Vereenvoudiging van de Schryftaal,* as well as the simplifications in grammar advocated by the same Association, have secured general acceptance in University circles. Luckily they have not had to face the opposition of any moth-eaten Academy, though even in Holland there are many individual opponents still unconverted.

The necessity for the economy of space prevents me from giving special instances of French and Dutch simplifications. I will simply state my conviction that changes in similar directions would help English better to fulfil the function of world-tongue.

Method of Simplification.

It is a difficult task to state in what way the simplification of English could be brought about most effectively.

Owing to the nature of the case, any changes must be carried out under the authority of the Imperial Government in conjunction with the Universities and great educational institutions of the Empire. In any case the French bureaucratic method is better than the Dutch private one, because the one who pays the piper can best call the tune. If once the reformation were accepted in the State-aided schools of the Empire, its further progress would be rapid.

The decision of particular changes to be adopted would have to be made by a fitly-constituted Commission acting under Government control. In any such simplification the co-operation of the United States should be secured, for uniformity of English throughout the English-speaking world is certainly desirable.

Why should we not aim at an *entente cordiale* of this nature? At present we seem to be rapidly drifting apart in grammar, vocabulary, and pronunciation.

Conclusion.

I have dealt with the simplification of grammar and spelling, but so far I have said nothing about the simplification of pronunciation. At present there are many thousands of cases of words which have two or even three so-called "correct" pro-

nunciations. I cannot enlarge on this topic now, but I should like to emphasise the desirability of having some properly constituted authority to determine specific cases of disputed pronunciation. Of course, periodic revisions of judgment would have to be made, but the same would apply to the general system of simplification. At present we are at a dead-lock. Usage and custom are as powerful as they have ever been, but our grammarians are as unchanging as the Pyramids, and so stupid that they cannot even agree among themselves about grammatical terminology.

If any writer of an English grammar were to accept the Split Infinitive, for example, he would be treated by the pedants with such contumely that he would have to recant. We English-speaking people are like Laocöons in the deadly grip of the pedant-snakes.

In conclusion, I should like to make it clear that I mean to be only moderate in my demand for change—not like the Professors of Language whom Gulliver met in Laputa, one of whom only wished to abolish all *polysyllables,* while the other actually wished to abolish *all words whatsoever.*

Cattle Ranching in Rhodesia.—At the fifty-first general meeting of the Liebig's Extract of Meat Co., Ltd., held in London during August, the Chairman stated that the Company had, on its ranches in Rhodesia, a nucleus herd of over 20,000 head of cattle, which are being graded up by the importation, from time to time, of Sussex and Aberdeen Angus bulls and heifers, the first cross calves of both these strains showing marked superiority in weight of the native cattle, to which they do not appear to be inferior in hardiness.

South African Asbestos.—The Imperial Institute has issued a report on a small consignment of blue asbestos which had been sent from South Africa in 1915. Samples of the consignment were submitted to several firms of manufacturers and merchants for expressions of opinion. Three firms who utilise blue asbestos placed the value of the material represented by the samples at from £28 to £50 per ton. The demand in the United Kingdom for crocidolite asbestos, to which variety the sample belonged, appears to be somewhat limited in comparison with that for the chrysotile variety.

PROFESSOR FREUD'S PSYCHO-PATHOLOGICAL THEORIES.

By G. T. Morice, K.C., B.A.

Before the present war turned the attention of science from the improvement of the conditions of mankind to the means of destroying human life, one of the subjects that excited special interest was *psycho-pathology*. The use of this word sounds rather pedantic; but it is really a very convenient term to describe morbid, disordered, or simply abnormal or unusual conditions of the mind. A great impetus was given to this department of study by the theories propounded by Professor Freud, of Vienna. Those theories, although their practical application has been chiefly directed to the treatment of insanity, hysteria, or other nervous disorders, cover such a wide area—extending, as they do, to such matters as the explanation of dreams and of ordinary mistakes in words and actions—that any person, who is interested in the scientific study of human nature, is justified in investigating and criticising them. Moreover, it is not unlikely that they will play a practical part in education, and even in the administration of justice, though it seems to me that to do so they will have to take a more scientific form than as now presented.

The two main features of Freud's teaching may be said to be the importance he attaches to the working of the unconscious mind and the method he employs to trace its working—the method of psycho-analysis. Before dealing with his system, it is well to understand one or two terms that he employs. A conveniently vague term that he often uses is a *complex*. A complex of the mind has been described as a system of connected ideas with a strong emotional tone and a tendency to produce actions of a definite character. But one can best understand what is meant by examples. Thus a hobby is a complex. A person, for instance, has a hobby for photography. He wishes to snapshot everything he sees, and his mind runs on photography, and he is inclined to divert conversation into the same channel. There are, however, complexes of an entirely different character. A young man or woman is in love. This is a complex. Disappointment in love leaves behind a complex of a painful character. There has been a *repression* of the complex, to use another of Freud's favourite terms. The complex is then a skeleton in the mental cupboard.

A well-known psychological experiment consists in making a list of words and repeating them aloud to the subject, who has immediately to call out the word suggested to him by each word in the list. An instrument is used which records to a fraction of a second the interval in each case between the utterance of

the word in the list and the response of the subject by calling out the word suggested. It is found that the interval is longer than the average when the word in the list evokes some association of an emotional character. In this way the wrong acts of persons, especially young persons, have been detected by the record of the fact that the intervals of responses are longer in the case of words in the list which are associated with the circumstances of the wrong act. Such words touch a complex of the subject; and no doubt the same result would be obtained when the complex was of a more permanent description, such as an old grief or disappointment, or pleasure associated with a hobby.

A complex forming in the mind of an individual may be one that his better nature condemns. A person may have a passion for something that is forbidden, a weakness of which he or she is ashamed. Then arises a state of tension, a *conflict* between the complex and the higher social tendencies. In the mind of the better sort, the complex will have the worst of the conflict, and the result will be its repression. The repressed complex, on the other hand, need not necessarily be bad from a moral point of view. It may be innocent in itself, but opposed to conventional views, or even merely condemned by prejudice. The idea of a mental conflict is one of the salient features of Freud's system.

When the complex is thus repressed, whether by the will or external forces, it is not necessarily eliminated from the mind. Driven as it were from the surface, it begins its underground working. Banished from consciousness, it still operates in the unconscious mind, and yet keeps striving to manifest itself in consciousness. It will seize an opportunity to do so when the repressing forces are not on the alert, when the mind of its victim is exhausted by illness or exertion, when he is dreaming or day-dreaming, when he is under some relaxing influence, such as alcohol or a drug. And in order to evade the vigilance of the higher feelings, it makes use of all sorts of disguises. Thus the delusions and hallucinations that show themselves in the mind of the insane and hysterical may have no apparent connection with the repressed tendency or complex. For instance, a woman whose insanity resulted from a disappointment in love had a hallucination in the form of a constant smell of burnt pudding. It was afterwards discovered that she had been making a pudding at the time of a crisis in her experience. In the same way the imagery of a dream may have little superficial resemblance to the tendency that was suppressed by the dreamer in his waking hours. Freud, who has written a work on the subject of dreams, describes their imagery as being *symbolical* of the repressed complex. He regards even the apparently meaningless symptoms of the hysterical person, such as repeated objectless movements, incapacity to stir a hand or a foot, loss of the power to exercise one of the senses—even these he regards as an attempt of the complex to express itself. Mistakes in speaking

and writing, forgetting words and names, he also treats as belonging to the same category.

To trace the connection between such pathological symptoms and the complex in which they originate, he applies the method of psycho-analysis, which involves the investigation of the experiences and mental associations of the individual. There is nothing very novel in this method. But I fancy that before Freud's time the alienist or specialist in nervous diseases paid little attention to the particular mæanderings or delusions of his individual patient. And it may be that Freud, if he has not discovered any new region, has discovered that certain neglected regions are worth exploring.

There is great divergence of opinion as to the utility of Freud's theories and consequent treatment of mental disorders. Dr. Mercier, who is no doubt an authority, in a recent issue of the *Nineteenth Century* refers incidentally to Freud's system, and appears to treat the whole thing as rubbish. But his dogmatic and intolerant attitude hardly inspires one with confidence in his scientific judgment. On the other hand, it is claimed that persons suffering from hysteria and other nervous disorders have been benefited by being shown the origin of their delusions or mental disturbances. It seems to me, as a layman, that, even though there may be no special virtue in the Freud treatment, the patient in nervous ailments, even more than in physical ailments, would be benefited by the relief afforded when the mystery as regards his complaint is removed and his mental disorder is explained to him. But these are matters on which, as a non-medical man, I shall not venture an opinion. What we are justified in criticising is the bearing of Freud's theories on *ordinary* life. We are, so to speak, invited by Freud to such criticism, as he has written an untechnical work (which has been translated into English), namely, "The Psychopathology of Everyday Life."

This book, which, if not rigidly scientific, as at least suggestive and interesting, deals with such matters as the forgetting of names and words, and the substitution of wrong names and words, mistakes in speech, reading and writing, and in actions, forgetting of intentions, and other errors of every-day life. To explain these Freud applies his theories, his position being that such mistakes are not merely mechanical or superficial, but the purposive or *motivated* operations of the unconscious mind, produced by complexes, repressed or otherwise, just as the delusions and other symptoms of the insane. To give a typical example (before coming to the actual instances), in speaking you substitute the name Johnson for the name Jobson. This mistake would ordinarily be supposed to arise mechanically through the resemblance of the names. But you apply the method of psycho-analysis to yourself, trying to trace any associations connected with the name Jobson. Perhaps you then remember that years ago a man of the name of Jobson insulted you or was your suc-

cessful rival in love or ambition. According to Freud's theories the reason why you substitute the name Johnson for Jobson is because the unconscious mind avoids the name associated with a painful complex, and substitutes for it a name similar in sound. Or the complex might operate by the mere forgettting of the name Jobson, although it would naturally be familiar to you. Freud does not deny that forgetting may occur in a simpler fashion; but he appears to believe that at least most cases of temporary forgetting are to be explained in this way.

The following are some of his instances:

A patient asks Freud to recommend him a sanatorium in the Riviera. He thinks of a sanatorium and recollects the name of the doctor in charge, but cannot remember the name of the small place where it is, and has to ask the ladies of his family. The name of the place turns out to be Nervi. This explains his forgetting. In his profession he has enough to do with nerves.

Mr. Y falls in love with a lady, who soon after marries Mr. X. Mr. Y was an old acquaintance of Mr. X., and still has business relations with him. But he (Mr. Y) can now never remember his name, and on wishing to correspond with him has to ask other people his name.

A person, in taking an oral examination in philosophy, gained credit for greater knowledge than he possessed by saying he had long taken an interest in a philosopher Gassendi, whose name he had only heard by chance a few days before. He says, "I believe it is due to my guilty conscience that even now I cannot retain this name in spite of all my efforts."

A patient telephoned to Freud for an appointment, and also wished to know the fee, which was 10 dollars. After the examination he again asked the fee, saying: "I don't like to owe money to anyone, especially doctors. I prefer to *pay* right away." Instead of pay he said *play*. He took out his purse; but to his apparent annoyance found that he had only 4 dollars with him. He promised to send a cheque for the balance. Freud's opinion that the man was *playing* with him was confirmed when, on afterwards sending out his bill, the letter was returned by the post office marked "Not found."

A lady patient, who had made an appointment, wrote that she was sorry she would be able (meaning *not* be able) to keep it. Freud thought at the time she was merely making an excuse, and found out afterwards that she had been persuaded by her friends not to consult him.

The motive of the unconscious mind sometimes appears to be praiseworthy; sometimes the reverse. Freud gives some instances where his unconscious mind seemed to be more respectful to his wife than his conscious mind. On one occasion he had wished to make merry with an intimate friend over a statement of his wife a few hours before. But he found he could not do so, as the statement had passed completely from his memory.

He gives another case where a different spirit was shown.

A man was urged by his wife to attend a social function, which did not interest him. He yielded to her entreaties, and began to take his dress-suit from a trunk, when he suddenly thought of shaving. After shaving, he returned to his trunk, but found it locked, and, in spite of a most diligent search, the key could not be found. As it was Sunday evening no locksmith was obtainable. The function had, accordingly, to be abandoned. On the trunk being opened next day, the key was found within it. The man had unconsciously dropped the key in the trunk and sprung the lock.

As this paper may be too long, I shall not give more of Freud's examples. I shall state my own view of his theory; but I should also like to hear what others think of it. In order that the problems may be made clear, I shall put them in an alliterative form. The first question is then: "According to your experience, are mistakes generally *motivated* or *mechanical?*" If they are motivated, then I think we should make a distinction which Freud, so far as I know, does not make, but which seems to me to be important. We should examine whether the motivated mistakes consist in something being let out or expressed, which one wishes to conceal, as in the case of the man who said "play" instead of "pay," or the woman who wrote "I shall be able" instead of "*not* be able to keep the appointment"; or whether they are the result of an unconscious striving to repress something that has unpleasant associations, as in the case in which the man forgot the name of his rival. In other words, are the motivated mistakes the *expression of a repression or the repression of an expression?*

Persons engaged in education have special opportunities of studying mistakes of others, and probably it is easier to trace motives in the comparatively simple minds of the young. I can only speak of my own mistakes. So far as my observation goes, my mistakes in words and forgetting of names are not motivated, but mechanical. When I use a wrong word it is simply because it resembles the word I intended; or I repeat a word that I have used before; or I use the word that is the opposite of the word I meant to use, as when in a law case I say "the defendant" instead of the "plaintiff." When I repeat poetry I use a wrong word in one line because I hark back to an earlier line, or anticipate a later line; or I go wrong by using a word similar in sound to the word that ought to be used. For instance, in repeating Wordsworth's line, "With new-fledged joy still fluttering in his breast," I have said "blest" instead of "breast." In writing my mistakes are similar. In summing up the law on bills of exchange I noticed that where I had to write "*or order*" I tended to miss out one of the "or's." In fact, I have found, in my own case, no example of a motivated mistake.

On one occasion it looked like one. I had to play in a golf competition with a man of the name of Warne, and

I had seen the name on a list at the club-house. But I got into my head that the name of my opponent was Cairns, the name of the professional at the Club. I even addressed a letter to Cairns at Mr. Warne's address, which the latter luckily opened. After finding out my mistake I amused myself by applying the method of psycho-analysis, and seeing what associations I had with the name Warne. There came back to my memory the name of a lady acquaintance who had died suddenly. No doubt Freud would have explained the mistake by the unconscious striving to avoid a name with a painful association. But I am inclined to think the explanation would be incorrect. The name of the person I remembered was spelt Warren (not Warne); and although the sound is the same, I visualise words rather than go by sound. Besides, the association with the name was pleasant rather than otherwise, as happens when we have enjoyed the society of a deceased person, while we have only heard by report of his or her death.

On the other hand, although I have not lighted upon specific instances in my own case, I cannot help thinking that we do forget and make mistakes through the unconscious avoidance of painful associations. I have more than once remarked how soon unpleasant incidents seem to pass from the memory, especially when body and mind are in a particularly healthy state. A veil seems to be drawn over the recent unpleasant matter; it seems already to belong to the remote past. As a member of the legal profession, I am inclined to agree with Freud, when he says that the conception of motivated forgetting has not yet been sufficiently recognised in the estimation of evidence or testimony in courts of law. A witness is bullied because he has forgotten something that goes against his sympathies in a case. The forgetting may be quite honest, springing from an unconscious erasure from his mind of what was unpleasing. And just as the complex may have a negative, so it may have a positive effect; a person thinks he remembers what is congenial to his disposition. Some years ago there appeared a book by the late Countess of Cardigan, containing a number of scandalous reminiscences, many of which, I understand, were entirely untrue. One can well imagine that a coarse-minded person might easily have faulty recollections of a sort congenial to her mind.

I also agree with Freud when he refers to the tendency to exclude from national legends and traditions anything that is painful to the popular feeling. We shall probably have an unfortunate example of this in the ease with which the German atrocities in Belgium and France will be forgotten by the German people, even if they are ever credited by it. It will be with the nation as Nietsche, in a passage quoted by Freud, says it is with the individual: "I have done that," says my Memory. "I could not have done that," says my Pride, and remains inexorable. Finally my memory yields.

NOTES ON THE HABITS OF A FEW TRAP-DOOR SPIDERS FOUND IN ALICEDALE, CAPE PROVINCE.

By Frank Cruden.

(*Plates 27, 28.*)

Many of our South African trap-door spiders have been named and described, but apparently few observations on their habits have been recorded. My notes, though incomplete, may therefore serve the purpose of adding somewhat to the stock of human knowledge concerning the architecture and life-histories of these interesting creatures, a subject which has always appealed greatly to the sympathies and imagination of naturalists.

These notes relate to rather more than half of the species which occur at Alicedale, where I have found quite a considerable trap-door spider fauna within the last two or three years.

The localities occupied by the several species of any one genus are sometimes sharply separated, but in other cases are coincident.

The genus *Moggridgea* is represented by four species in this vicinity. *M. crudeni* and *M. rupicola* often occur in close proximity to each other, but *M. coegensis* and *M. terrestris* do not, as far as I have yet observed, live near any other species of this genus.

The two local species of *Acanthodon*—*Abrahami* and *Crudeni*—are often found together, and also in company with species of other genera. In one small claybank I found both *Acanthodons, M. crudeni, Stasimopus*, and an *Ariadne* within easy reach of each other.

At East London two species of *Acanthodon* were found together, one with an overlapping lid, the other with a lid fitting closely into the mouth of the tube and flush with the ground.

Our two species of *Pelmatorycter* I have never found together, but *P. parvus* and the two species of *Acanthodon* often occur in the same spot.

One of the species here dealt with (*Bessia minor*) seems to have quite a unique type of trap-door.

Most of the technical descriptions of the Alicedale trapdoor spiders have been published by Mr. John Hewitt in the Records of the Albany Museum, Grahamstown.

Stasimopus, Sp. (*aff.* Patersonæ-*Hewitt*).

(*Rec. Albany Mus.*, **3**, 30, 82.)

Locality.—This is the largest of all the trap-door spiders found in this neighbourhood. It usually constructs its nest in

clayey soil, most frequently on open flats, but occasionally in sloping banks or under the protection of projecting stones. Nests often occur in small groups.

The Lid.—The lid is circular in shape, and fits into the mouth of the tube, so that the upper surface lies flush with the ground. The inner surface is white, except the bevelled brown margin which fits into the expanded rim of the tube. Near its centre are several holes arranged, more or less, in a circle. Into these the spider inserts her fangs and claws when she has occasion to close her door against intruders, a considerable force being then required to pull it open. The size of the lids of nests occupied by adults varies somewhat. The diameters of three large ones I measured were 25, 25, and 32 mm., and the respective lengths of the tubes 115, 190, and 180 mm. From 6 to 8 mm. is a common thickness for these lids at the centre. Lids often show clearly the successive stages in their construction, and evidently indicate that the nest had originally been of very small diameter, and had been enlarged to suit the growth of the occupant. One lid showed eight distinct enlargements, the first or original lid being 9 mm. and the eighth 32 mm. in diameter. The newer lids are always constructed under the older ones, and attached to them.

During the period of egg-laying, hatching, and evidently for some time after, the lids are fastened down securely by means of a plug of clay built downwards from and attached to the lid, and completely filling up the mouth of the nest. This to *Stasimopus, Acanthodon Crudeni* and the various local is, as far as Alicedale trap-door spiders are concerned, peculiar species of *Moggridgea* merely fastening down their lids with web. As these clay plugs are unlike the soil near the nests, the difference in colour may be due to some softening medium supplied by the spider herself. The lower surface of these plugs is concave, and shows clearly the marks of the spider's fangs.

Tube.—The nests usually enter the ground with a slight slant. Most of them have one bend, but nests with two or more bends are not uncommon. This, however, is only a matter of necessity, because of stones or other obstacles in the way. The tube varies in diameter—one which was 25 mm. at the mouth was only 16 mm. at a depth of 25 mm. down the tube.

Lining.—The lining is of tough, felted web, and is very white in colour.

Excavating.—One one occasion I dug out a full-grown female, and took away an inch of the tube with the lid attached. This was sunk in very wet clay until the lid was level with the surface. The whole was allowed to dry somewhat. the spider was returned to its very much shortened abode, which it began straightway to deepen by digging out the earth. It was seen to be busy, head downwards. Presently it turned with some difficulty in the

tube, pushed up the lid, and appeared with a pellet of clay between its fangs. It then inserted the front pair of legs behind the pellet, and shot it out a distance of from 12 to 18 inches. This was repeated with great steadiness for several hours, neither light nor darkness making any marked difference to the rate of work. The spider left off only when she reached the bottom of the box in which the clay had been put.

Feeding Time.—As they are very sluggish during the day, and lively and pugnacious when interfered with at night, it would seem more natural that they should seek their prey in the darkness. For observation purposes I transferred three full-sized females, with their nests, to my garden. At night I have often examined them by lantern light, and have usually found the lids very slightly but distinctly raised. On drawing a straw, or twig, gently past the margin of the lid the spider, on every occasion, shot out and caught hold of it, but relinquished it instantly on finding what it was. Once I placed a beetle beside the lid and drew the straw past as before. The beetle was taken indoors instantly. The same happened with a large moth. On no occasion have I seen any of these spiders completely out of their nests.

Males.—I have found in all 18 adult males of this species —all in lidded nests of small diameter. One nest was only 39 mm. in length and 7 mm. in diameter at the mouth. At the bottom it was somewhat wider, probably to permit the occupant to turn freely. In all cases these males were in nests whose lids were securely fastened down with small plugs of clay on the inside. The fang markings were very distinct. The tubes were lined with a very thin coating of web, very different from the tough thick felt of the nests of adult females. I have never found a male Stasimopus outside a nest, and it must only be after very heavy rain that they are able to dig their way out.

Further Observations.—On one occasion I placed three females in holes bored for them in the ground. Next day all three were found to have hidden themselves under a loose mixture of soil and web. Secure under this protecting cover, two of the spiders completed the lining of their nests in three or four days. One of them, in a single night after rain, began and finished its lid. The second had to construct her lid about an inch below the mouth of the tube, probably because of the looseness of the surface soil at that spot. The third spider did not take the trouble to line her tube, and was flooded out during rain.

Occurrence of Nests.—Nests of all sizes are very frequently found in close proximity to each other, and rarely occur alone.

ACANTHODON CRUDENI *Hewitt* (Pl. 28 F and K).

(*Rec. Albany Mus.*, **3**, 18.)

Locality.—This species is found in sloping claybanks, on

flats beneath trees and bushes, but very often right in the open without any protection of any kind.

Lid and Tube.—The lid is thin, D-shaped, and is concave on the under surface. It does not fit into the tube as in the case of *Stasimopus*, but overlaps the mouth, which projects slightly above ground. The margin of the mouth is turned down into a sort of rounded rim to which pieces of dry grass or other material are attached. These, though not very strong, may perhaps strengthen the projecting portion of the tube. The centre part of the inner surface of the lid is made of white felted web, and fits the circular opening. Outside that is the concave projecting margin which overlaps the rim of the tube. During the incubation period the lid is fastened down by a collar of web joining the margin of the white central disc to the sides of the tube. The tube is usually from four to six inches long. When lifted and released, the lid shuts as with a spring. Were it not so arranged, its lightness would render it liable to be easily blown open by the wind or lifted by the spider's enemies. On one occasion only have I seen a lid open during the day, but it was instantly closed on my approach.

Occurrence of Nests.—Nests are often found in small groups, but isolated nests are quite common.

Males.—I have found over half a dozen adult males in the months of February, March and April—all in lidded tubes like those occupied by females. At East London, at the end of June, 1915, I found two smaller species of *Acanthodon*, and was very fortunate in securing several males of both. In all these cases, however, the males were found in tubes roughly closed but without distinct lids.

Further Observations.—On one occasion I put a female into a hole bored in clay. The tube was lined, and the lid put on in a few hours. Small shavings cut from matches were placed near, and these the spider fixed all round the mouth of its nest.

ACANTHODON ABRAHAMI *Hewitt* (Plate 27 D).

(*Rec. Albany Mus.* **2**, 473.)

Locality.—This species is commonly found under the lee of stones, and on sloping ground usually protected by vegetation. It has also been frequently found in horizontal rock crevices, but seldom on flat ground.

Lid and Tube.—The tube as a rule projects from 1 to 2 inches horizontally above ground, and looks, to the casual observer, like an exposed dead root or dry stick. This part of the tube is very much thickened, and is in consequence much stronger than the part underground. The tubes are usually from 4 to 6 inches in length, and are seldom more than half an inch in diameter. They are often very tortuous, being frequently found almost encircling stones.

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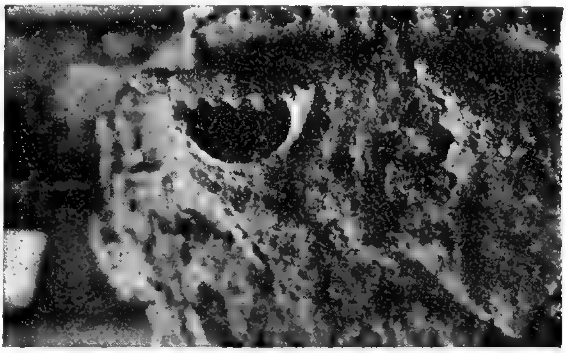

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F. CRUDEN.—NESTS OF TRAPDOOR SPIDERS.

Nests with several old lids are often found. Evidently when a new lid is deemed necessary the tube is elongated beyond the old lid, which is then left on the upper side of the tube, and a new lid is constructed.

The lid always hangs vertically, and consists of two well-defined parts—a thin wafer-like disc, which fits closely into the mouth of the tube, and to which the spider holds firmly when the lid is disturbed, and a very heavy bevelled portion made of web and earth. This heavy part is attached to the disc at its centre and hinge, but not at the margin. There are two holes on the outer hollow surface of the bevelled part, which lead through to the wafer portion, but of what use they are I cannot conjecture, as they do not in any way communicate with the interior of the tube, and in older nests they are often silted up. These holes are to be seen in the very smallest lids, not much more than an eighth of an inch across the hinge. The lid shuts quite close on account of the weight of the bevelled part, which is evidently expressly meant for that purpose.

Lid Building.—On October 28th I brought in a nest from the veld, embedded it in earth in a box, and cut off the lid. In order to observe it closely, I placed a good lens in front of the nest, and used the light of a bright lamp. In a few moments the spider came to the lidless mouth, at once turned on her back, and worked on the remains of the old hinge with fangs and claws, evidently preparing for the new lid. She then came to the entrance, and carried in a pellet of soil in her fangs. Turning on her back as before, she attached this to the base of the old hinge with claws and fangs, and fixed it with web. This was done all along the base, after which she applied her spinnerets and spun several strands of web behind and along the margin of the newly-attached earth, frequently carrying the threads from the hinge along the roof of the tube. To these new marginal strands fresh attachments of clay were made, and after each the spinnerets were again used. Frequently the spider was seen to knead the pellets with her fangs before fixing them. After the foundation of the lid had been laid, the attachments were made at the middle, and gradually the arc of a circle was formed. Very often the whole fabric was pulled inwards to ensure the free working of the hinge and the correct size of door. When this thin lid completely filled the mouth of the tube the spider closed it and rested from her labours—three and a quarter hours after commencing work.

It should be mentioned that each time the spider went to collect earth she remained motionless for a time at the mouth, perhaps making sure that all was safe. This seems to indicate a certain degree of intelligence, but on the other hand, when using her spinnerets, she frequently extended her abdomen well beyond the mouth of the tube in order to get longer strands of web, thereby exposing the most vulnerable part of her body to

danger. On no occasion did she come right out of her tube to collect earth.

I kept the nest under observation for a month in the expectation of seeing the bevelled portion added to the thin disc of the lid, but nothing was done. Concluding that the spider was dead, I broke open the nest, and found her carefully looking after a deposit of eggs enclosed in a snow-white sac, which was attached to the sides of the tube by a few strands of web. Evidently she was too much occupied with maternal cares to find time to complete the lid.

Males.—Two adult males were found in February, 1914. They were much lighter in colour than the females, and were living in nests of exactly the same type as those occupied by the females. The lining of the tubes, however, was of much whiter web.

Of nine others found in February, March, and April, 1916, only one was in a nest with a properly constructed lid. All the others had lids fastened down securely, and these seemed to be very roughly finished off.

Occurrence of Nests.—Nests are often found in small colonies, but isolated ones are not uncommon.

Besia Minor *Hewitt* (Pl. 28 G, H and I.).

(*Rec. Albany Mus.* **2**, 469.)

Locality.—This species is never found here except under the shelter of projecting rocks and banks, usually in soft, crumbly ground, which renders it almost impossible to dig out the nests in a complete condition. Occasionally they are found in clay, and even in moss.

Nest and Lids.—From a structural point of view the nest of this spider is the most interesting we have in this district. Unlike all the others, each nest has two lids, and is exceedingly short, being seldom more than an inch and a half from lid to lid. The lids are opposite and at the same level. The chamber between them is much wider than the entrances, and has a sloping bottom. In several cases nests have been found with a vertical tube leading down from the bottom of the chamber. This is exceptional. One of these measured 3 inches from the roof of the chamber to the bottom of the tube, while the distance from door to door was 1¼ inches. The doors across the hinge measured half an inch, and the average width of the vertical tube was three-eighths inch. There was a slight widening of the tube near the bottom, probably for convenience in turning. The lids, unlike those of any other trap-door spider here, are constructed in halves, as shown in the plate. Owing to this peculiarity the lids remain open when pushed outwards, and can be closed very tightly when pulled inwards.

The lids vary considerably in width (from three-eighths to five-eighths inch) across the hinge even in the case of fully

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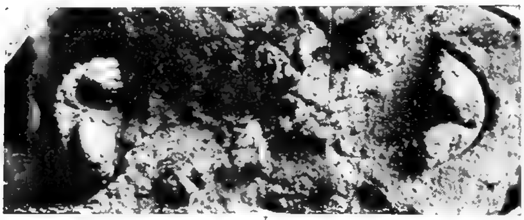

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F. Cruden.—Nests of Trapdoor Spiders.

developed specimens. In most cases the lids are slightly weighted by means of two carefully-prepared masses of clay placed one on each side of the sinus at the margin of the lid opposite the hinge.

Feeding Time.—On one occasion I placed a case-bearing caterpillar beside a nest kept for observation under glass. Next morning the case, torn and empty, was found beside one of the doors of the nest. Another specimen in captivity was found wandering about at night near its nest, one lid of which was standing right open. These two instances would seem to indicate that night is the time for feeding.

General.—On several occasions I have put a large bluebottle fly in at one door of a nest, with the invariable result that the spider bolted out, evidently in terror, at the other door. Small houseflies, however, were accepted readily.

The frequent opening of one lid annoyed one spider so much that it blocked up that entrance with earth and web, and used only one door afterwards.

One spider during the egg-laying period wove a web across the opening, under the lid, but not attached to it. Whether this is usual or not I cannot say, as I have never before found nests with eggs or young.

When a spider is evicted from her nest, she seldom shows fight, as *Stasimopus* usually does.

Males.—I have found only two males of this species in the months of February and March, both occupying nests exactly the same as those inhabited by females.

Occurrence of Nests.—Nests usually occur singly. On no occasion have I found more than three nests at the same spot.

MOGGRIDGEA CRUDENI *Hewitt* (Pl. 27 B and C).

(*Ann. Transv. Mus.* (1913) 4 [1].)

This species was first found in earth-filled rock crevices and in close proximity to the nests of *M. rupicola*. The lids of these were much thicker than those of *M. rupicola*, and were smooth-edged and not quite oval in shape. Since then I have found many nests in the veld, under the protection of vegetation, but possessing in most cases very distinctly crenated lids of the D type. The tube is very short—seldom more than 2 inches long—narrow at the mouth, and expanding into a fairly wide chamber near the bottom, and lined with hard, smooth, felted web. The mouth of the tube has a horizontal expanded collar. The central part of the interior of the lid is white, and projects somewhat. This, coupled with the overlapping of the scalloped edge, leaves a concave rim, which fits on to the expanded portion of the mouth of the tube.

Lid Building.—On one occasion I put six females into holes bored for them in earth in a tin. This was at 6 p.m. Very soon all were busy lining the holes with web. By 9 p.m. two

lids were sufficiently completed to cover the mouths of the tubes, but the spiders were still working at them, heads downwards, and spinnerets busy on their under sides. On watching one which was not so far advanced with lid-making, it was found that every now and then she emerged to collect small quantities of earth, with which she disappeared into the tube, to reappear presently and fix the earth to the outer margin of the lid with fangs and claws.

Judging by the interval that elapsed between her entering the tube and reappearing, one might suppose the spider had to mix the soil with some substance to give it the consistency necessary for building. After fixing, as already stated, she again turned her spinnerets to the new part, and strengthened it by several layers of web.

By 11 o'clock a third spider had the opening covered by a full-sized lid, and by daylight all lids but one were completed. The last spider remained inactive for several days before it set to work on its lid.

Much had to be done towards thickening the lids and in making the crenated, over-lapping margin, but this was at length accomplished by all.

Males.—One male was found in a nest with very small, almost round, lid in March.

Incubation Period.—Eggs have been found in December, January, and February. At this time the lids are always firmly fastened down with web.

Moggridgea Rupicola *Hewitt.*

(*Rec. Albany Mus.* **2**, 462.)

The nests of *M. rupicola* are always formed in rock crevices, or attached to the underside of overhanging ledges. In the former case the lid has its hinge above the opening; in the latter it is below. The position of most of the nests suggests that the spiders choose narrow crevices, so that the top and bottom may be attached to rock. These nests are always strengthened with earth, and are never found except in a more or less horizontal position. They are always very short—from an inch to an inch and a half being usual in the case of those with adult occupants—and widen considerably towards the interior.

The lids are very thin, fragile, and wafer-like, and are nearly circular. When closed they are very difficult to detect, as they fit very closely into the mouths of the nests.

When disturbed the spider holds on firmly with fangs and claws, which it inserts in openings in the centre of the lid.

Feeding Time.—I cannot say when this species usually feeds, but on one occasion, when looking for nests under a ledge, I was fortunate enough to see a spider secure its prey. A small fly was walking past a nest when, like a flash, the lid flew open, the fly was caught, and the spider vanished with its victim.

Males.—The males of this species are found in nests exactly like those occupied by females. I found four in the months of March and April.

MOGGRIDGEA COEGENSIS *Purcell* (Pl. 27 A).
(*Ann. S. Afr. Mus.* **3**, 71.)

This is the largest of the local species of *Moggridgea.* They are probably fairly abundant, but so far I have found them singly and seldom. At Sidbury lately a group of about half a dozen was found at the base of an antheap. The nests are from 4 to 6 inches deep, the lids are D-shaped, and overlap the mouth of the tube. They are very thick, and are often disguised with pieces of grass and leaves worked into the upper surface. The inner surface has the fang markings very clearly shown.

On one occasion, when digging up a patch of moss-grown earth, I found in its midst a nest whose lid was covered with moss, so that it was absolutely impossible to detect it when viewed from above.

These lids are always fastened down with web during the incubation period. The eggs are enclosed in a snow-white sac, attached to the sides of the tube, in such a way that the spider can easily pass.

The lids of six adult specimens measured about an inch from side to side, three-quarters of an inch from hinge to front, and from one-eighth to one quarter inch at the thickest part. As yet I have found no males.

MOGGRIDGEA TERRESTRIS *Hewitt.*
(*Rec. Albany Mus.* **3**, 13.)

Up to the present this species has usually been found on bare flats under the shade of trees and bushes. The lids, which are D-shaped, lie flat, just above ground, but not flush with it. They are thicker than those of *M. rupicola* and *M. crudeni,* and resemble the latter very closely except that they have no crenated edge.

The white central portion of the inner surface of the lid projects slightly, and fits the mouth of the tube. The rim outside this is brown, and lies on the ground surrounding the tube.

In all cases examined the tubes were longer than in either of the two species just mentioned. The longest I have found measured 3½ inches. At the mouth and halfway down the tube the diameter was a quarter of an inch. Midway between mouth and middle, and also between middle and bottom of tube, it widened to a third of an inch. This very distinct narrowing and widening of the tube occurs without exception in this species, but it is unusual to find the narrowing and widening repeated as in the case mentioned.

The lining of the tube is not so thick and tough as in any of the other three local species of this genus.

Nests are found isolated. I have never seen two together. Up to the present no males have been found.

PELMATORYCTER PARVUS *Hewitt* (Pl. 28 M).

(*Ann. Transv. Mus.* **5** [3] (1916).)

This species is usually found in loamy soil, not in clay. The tube bifurcates at the surface of the ground at an angle of about 120 degrees. The two branches project to a distance of from 18 to 20 mm., and to the casual observer look like dry twigs or roots. There are no lids, but the tubes are folded in at the mouth, and each ends in a point. When opened out and released, the tubes immediately resume their folded position.

The lining is of very white felted web.

The nests are usually from 150 to 175 mm. in depth, and about 3 mm. in diameter. They occur in small colonies.

Eggs and young were found in January and February, and one male was got in May.

PELMATORYCTER CRUDENI *Hewitt* (Pl. 27 E).

(*Rec. Albany Mus.* **3**, 72.)

This species is much larger than *P. parvus,* and occupies a tube of relatively greater diameter—7 to 8 mm. being usual in the case of adult spiders. As in the case of the smaller species, the tube bifurcates, but this happens underground, and only one branch comes above the surface, the other being blind. The angle of bifurcation is between 90 and 100 degrees. The projecting part of the tube is folded, as in the smaller species, but it is not pointed. It also, when opened and released, resumes its folded position.

The length of the tube is much the same as that of *P. parvus.* The lining is less felted than in *Stasimopus,* but is is much whiter in colour.

Usually they occur singly, but groups of three or four are sometimes found. Up to the present I have seen them only on clay flats, from which in dry weather it is very difficult to dig them. There is an easier way of getting them, however, for when the mouth of the tube is gently scratched the spider, either, suspecting danger, pulls the folds more closely together, or pushes open the mouth in the expectation of catching prey. It is quite easy, then, to cut off their retreat by pushing the blade of a knife through the tube below the point of bifurcation. On one occasion I put two spiders into holes prepared for them in earth packed in a glass jar. In a short time the upper parts of these holes were closed up to form the blind arm, and the other branch of each was excavated right to the surface and finished off wth the folded mouth. During the day the entrances remained closed, but when examined at night they were found to be wide open, the spiders lying in the mouth on the alert for prey.

Explanation of Plates.

A. *Moggridgea coegensis* Purcell.—Entrance to the nest; about natural size.

B and C, *Moggridgea crudeni* Hewitt.—B is enlarged and shews the crenated margin of the lid and the entrance of the tube. C is only slightly enlarged, and shews the lower surface of the lids of two nests, the fang marks being clearly indicated.

D. *Acanthodon abrahami* Hewitt.—Lid and entrance to nest, about natural size.

E. *Pelmatorycter crudeni* Hewitt.—Shewing exterior portion of nest.

F and G, *Acanthodon crudeni* Hewitt.—Shewing entrance to nest and lid in side view and front view.

H, K and L. *Bessia minor* Hewitt.—H shews the lower surface of the lid and the entrance to the nest. K shews the two lids of a nest in dorsal view (this photograph is, however, a composite one taken from two slightly different points of view). L gives an end view of an open lid, also the entrance to a nest.

M. *Pelmatorycter parvus* Hewitt.—Shewing the external bifurcated portions of several nests.

Scientific Research in South Africa.—At the invitation of the South African Institution of Engineers, a Conference of Scientific and Technical Societies recently took place in Johannesburg, in order to consider the desirability of establishing an Institution for Scientific Research in South Africa. Amongst the resolutions adopted at the Conference were the following:—"The members present recognise themselves as bound to combine in taking such steps as may be in their power to hasten the scientific development of the resources of South Africa, especially in view of the coming commercial and industrial competition, and the obligations of this country to do its share in providing suitably for the present and future needs of the men who are fighting its battles, or who are disabled thereby, as well as the needs of their dependents, and the dependents of those who have given up their lives in defending the honour of the British nation"; and "That each of the scientific and technical bodies to be subsequently agreed on, which join together as a result of the resolution already carried, shall nominate not more than three representatives to act as a Central Committee. Such Central Committee shall elect its own Executive Committee and sub-committees"; also "That the members of Council for the time being of the various scientific and technical societies in South Africa and Rhodesia, to be agreed on in accordance with the previous resolution, shall form the General Committee." An Executive Committee of five was subsequently appointed, comprising two electricians, one mining engineer, an astronomer, and a metallurgist.

ON THE VARIABILITY IN THE NATURE OR TEMPERAMENT OF WILD ANIMALS IN CAPTIVITY, WITH SPECIAL REFERENCE TO SOUTH AFRICAN SPECIES.

By Alwin K. Haagner, F.Z.S.

It has often struck me during my six years' connection with the Transvaal Zoological Gardens—first as Superintendent and then as Director——how the temperament of a wild animal often changes in captivity—*i.e.,* how different it may become from the ordinary nature of the beast in its wild state. One peculiar point in this connection is the fact—first noticed by the late A. D. Bartlett (for many years Superintendent of the London Zoological Gardens—that, as a general rule, the descendants of wild animals *born in captivity* are much wilder than those captured in the field and subsequently tamed. This is especially the case with deer and antelope. We have had buck captured when half grown which had become so tame and confiding that they came up to me when I called them, and others, again, *born in the Gardens,* which dashed off at the approach of anyone, even the men who worked with them daily. One reason for this is no doubt the fact that an animal which is born in captivity—in a Zoological Garden, at any rate—is hardly ever "man-handled," whereas a wild caught antelope, or similar animal, would be almost continually handled by its owners or its caretaker on account of the artificial rearing which would be necessary. Another noteworthy fact is that animals vary individually amongst themselves to a considerable extent; this remark will be made clearer at a later stage of my paper.

Order Primates.

The members of this order are, as a general rule, unreliable, pugnacious, and even vicious in captivity, although in the wild state fairly timid and shunning the presence of human beings as much as possible. As, however, they are of such varied size, temperament, and habits, it would be best to divide them into their natural groups.

Manlike Apes (*Simidæ*).—The late A. D. Bartlett, in his book, "Life Among Wild Beasts in the Zoo," remarks on the habits of a Chimpanzee received by the London Zoological Gardens in 1883, and which, partly on account of its habits, he considered a new species. It subsequently proved to be the baldheaded Chimpanzee (*A. calvus*), but a specimen of the common Chimpanzee in the Pretoria Zoological Gardens has developed habits akin to those of Bartlett's baldheaded animal, and yet it is undoubtedly the ordinary species. Bartlett, as before-mentioned, at first considered the now historic "Sally" new to

science on account of the difference in its habits from those of former Chimpanzees in the collection. My personal opinion now is that individual animals of a species vary almost as much in temperament and behaviour as human beings, and no hard and fast rule can be laid down for their management. One has to learn to know the "personality"—to use an incongruous term —of each individual animal. I say this with reservations, but my meaning will become clearer as I proceed.

Baboons and Monkeys.—The Chacma Baboon and the Vervet Monkey are both fairly shy animals in the wild state, descending from their mountain fastnesses or leaving their thickly wooded retreats for the vicinity of human habitations, when driven to do so by hunger, or under cover of night. When young they make interesting and even lovable pets, but when adult their temper becomes uncertain, and they are not to be trusted. Individual examples, however, learn to love and fear their masters, and may be taught to do tricks requiring a considerable amount of intelligence.

One individual—a Chacma Baboon—in the Eastern Province of the Cape, was so attached to its master, who was maimed, that it assisted him in his work in various ways.

One Bonnet Monkey in the Pretoria Zoological Gardens was quite untameable, and could not even be placed in a cage with its own kind. The keeper, however, maintained that the brute liked and respected him, and would play with the animal despite repeated warnings from me. The end of the matter was that, without rhyme or reason, the monkey one day pounced upon its keeper and bit through his jugular vein. The unfortunate man was laid up in hospital for six weeks, and I had the animal destroyed.

We had some South American Capuchin Monkeys, bright and merry little fellows, full of fun and frolic, but positive little bullies, and they led one of their number—a grizzled old chap, who was unfortunately an abject coward—a terrible life until he was removed. Their delight in teasing and biting the unfortunate one was almost human (so far as the bullying element goes), and the natures of the animals were as different as one could possibly expect. The old chap subsequently became the staff pet, and was fondled and made much off by all the members of the staff, with the exception of one, whom he could not endure, although the man had done him no harm. He never attempted to bite unless he was deliberately frightened, when his cowardly nature caused him to retaliate without actually meaning to do so. Many Baboons or Monkeys bite from pure "cussedness" or contempt of man, and not because they are frightened, *although no doubt the latter is the reason why most of them do bite.* The following striking passage occurs in Bartlett's book, already mentioned:—

The variableness in the habits and dispositions shown by the monkeys selected for performing is well worthy of notice. Many of the different

genera are mentally, so to speak, far removed from each other; some of them are capable, by training and education, of being taught and made to understand the various duties that the teacher imposes upon them; while others, as among ourselves, are found devoid of the power of learning.

The trainers of monkeys well know the species best adapted to their various purposes.

Another habit, or rather practice, of the larger monkeys mentioned by Bartlett, and repeatedly observed by me, is that of yawning in order to show a new arrival their powerful canine teeth, and Bartlett interprets this as a warning or threat to the new-comer. They are quarrelsome in the extreme, and yet I have known Macaque Monkeys and even Baboons to be quite amiable in disposition.

Carnivora.

The following is Bartlett's opinion of a somewhat singular fact:—

The Lion (*Felis leo*) appears to breed more freely than any other species of *Felis*, and the number of young at a birth is greater, not unfrequently four, and sometimes five, being produced in a litter.

It is remarkable that these animals breed more freely in travelling collections (wild beast shows) than in Zoological Gardens; probably the constant excitement and irritation produced by moving from place to place, or change of air may have considerable influence in the matter.

This is a strange and certain fact, and is as true to-day as it was in Bartlett's days. In South Africa I have found it so. The Lions and the Tigers in the Zoological Gardens do not breed nearly so freely as those in the travelling menageries and circuses which have toured the country, and Bartlett's explanation may be the right one. However, temperament may also have something to do with it, and when a Zoological Garden has the fortune to obtain a good captivity-breeding strain, the birth-rate is as prolific as that of most menageries, as, for instance, the Dublin Zoological Garden, famed for its Lion breeding; and here, in South Africa, the Johannesburg Garden has certainly beaten Pretoria in this direction.

The members of the cat tribe are not famous for their fidelity or trustworthiness, so far as popular belief is concerned; but the larger members of the family, at any rate, belie the reputation of the smaller to a great extent. The following is the late Carl Hagenbeck's opinion on this point:—

It is a complete mistake to suppose that carnivores are vicious by nature; they are susceptible to kindness and good treatment, and will repay trust with trust.

Lions and Tigers, especially the former, would seem to be more to be trusted than Leopards and Lynxs, at least that is my experience. It was Carl Hagenbeck who first brought the variability of animal nature into prominence in the training of animals, and by means of selection according to temperament, he was able to prove that wild animals could be trained with much less harshness and cruelty than was thought possible by

the older school of animal trainers. This is so well described in Hagenbeck's book, " Beasts and Men," that I give it *in extenso*:—

With the lower animals as with human beings, real insight into their character can only be obtained by treating them sympathetically. This essential fact, which is now understood by all successful animal trainers, ought in no way to surprise us, for the brute intelligence differs from the human in degree only, not in kind. It is now universally recognised that each animal has its own peculiar characteristics, its own idiosyncrasies over and above the general psychological character which it shares with all other members of its species. This is a discovery I had to make for myself, and a most important one it is for the trainer, for I say, without fear of contradiction, that no trainer is fit for his vocation who is unable to read the character of the individual animals which he has to train. And so it came about that when I introduced the humane system of training, as I may call it, I not only substituted for the whip and the red-hot iron a kindly method of educating the creatures (based upon an intelligent system of rewards and punishments), but I also instituted the practice of studying the character of each individual before including it in a troupe.

In Pretoria we have three Lions (two females and a male. The young female, although menagerie-born, cannot be trusted, and always appears to be watching for a chance of seizing one. The old Lioness and the Lion, on the other hand, are tame and trustworthy, and during all the years that I have known them, have never attempted to bite or scratch me. They know me so well, too, that one call is usually sufficient to bring them out and up to the bars for the customary patting and stroking.

The two Tigers which we possess, on the other hand, are fierce, savage brutes. They show especial animosity towards their keeper, and seem to dislike everyone connected with the Gardens. They nevertheless remain supremely indifferent to the general public. Hagenback mentions several cases, however, where Bengal Tigers have been most trustworthy animals, and possessed excellent memories for the master whom they had learnt to know and to love.

The Cheetah is, according to Bartlett, " timid, gentle, and very excitable." I have found Cheetahs certainly gentle and rather shy, becoming excited at the approach of any unknown animal; but most carnivores would do this. Cheetahs seem to be more trustworthy than any of the other larger felines, and, as is generally known, they are trained and used by the Hindoos to chase and capture game, especially Blackbuck. When brought up with another animal, they retain this friendship when full grown. A Cheetah in the Pretoria Gardens grew up with a Baboon, and they were firm friends until death parted them. There is at present a full-grown example in the Pretoria Gardens which has a common cat for its companion, and very good friends they are too. In the cage next door to the Cheetah is a Leopard of about the same age, and, like it, hand-reared. The difference in the natures of the two brutes can be seen any day at meal times, as the Leopard becomes nasty when it sees blood, and has to be chained up before the keeper can enter its cage

with the meat, whereas the Cheetah's cage can be entered as fearlessly at feeding times as on any other occasion.

UNGULATA.

Pachyderms.—Elephants are, as is well known, wonderfully intelligent animals, but the males, when adult, are of very uncertain temper. Bartlett, who devoted much study to these huge animals on account of his fondness for them, says in his first book, "Wild Animals in Captivity," that when the males are about 20 years of age they require careful management. He also makes the assertion that although he knew the attacks of wildness of the famous African Elephant "Jumbo" could have been subdued by reducing his food supply, chaining him up, and flogging him, he feared disastrous results would ensue from kind-hearted and over-sensitive people. He goes on to say:—

> It is only those who have had experience in the management of an Elephant who are aware that unless the person in charge of him is determined to be master and overpower him, that person will lose control over him.

And later on, in the same book:—

> The stupid interference of people ignorant of the subject would expose the people in charge to be condemned.

Bartlett considered that, although African Elephants may not be as docile as the Indian species, they would prove quite as tractable and useful. "Jumbo" was exceedingly intelligent, and, as above mentioned, was an African Elephant. "Alice," the Elephant that followed "Jumbo," was also of this species. We possess a young African animal, answering to the name of "Dora," whose age I would now judge to be about ten or eleven years. Six months after we received her—she was wild caught in Rhodesia—we could ride and guide her about the Gardens as easily as the full-grown and well-trained Indian Elephant. She also learnt to beg within a few weeks, and is quicker and keener in this department than her older and better-educated companion. It is, therefore, a mystery to me why no use, so far, has been made of the African Elephants in this country, especially in Rhodesia.

Hagenbeck says in his work, "Beasts and Men," when giving some of his experiences with Elephants, that "clever animals are liable to moods with which it is not always possible to reckon." He then details an accident that he had with a *female* Elephant, which nearly killed him out of pure "cussedness," although females are seldom dangerous, and in this are quite unlike the adult males. The latter, as I have previously mentioned, often get out of hand during the "must" periods. However, to emphasise the variation of temperament of individual animals of a species, it is worthy of note that one of the tamest, most intelligent, and most affectionate Elephants ever possessed by Hagenbeck was an adult male.

The Rhinoceros is, on the other hand, a stupid animal. Bartlett says:—

> When very young and small it is usually not bad tempered . . . . but long before the beast becomes adult it is dangerous to enter the den or paddock when the animal is at liberty

Hagenbeck says they are easy animals to tame when young. This has been my experience with both our specimens. The male is now about eight years old, and just about adult. He is also beginning to become nasty, sometimes attempting to poke people who approach too near the fence. The little female purchased in December, 1914, is ridiculously tame, and walks solemnly up to the fence as soon as she is called by name. With the Hippopotamus I have not had any experience beyond the bull which has now been in the collection for over eight years, and which gets periods of unruly and uncertain temper much like the "must" periods of a male Elephant.

Deer and Antelope.—Bartlett has the following paragraph in his "Wild Animals in Captivity":—

> On the other hand, take the vegetable-feeding class, such as stags, antelopes, oxen, sheep, or goats; obtain any of these from their birth and rear them by hand, and in all instances, with few exceptions, they become, when adult, the most savage and dangerous animals in existence. . . . Another remarkable fact connected with these vegetable-feeding horned animals that have been bred in capitivity (not petted and handled) and reared by the parent, is that they are the wildest creatures in the world if anything is attempted to be done with them in the shape of catching, packing up, or moving them from one place to another.

This I can heartily endorse. The males of Deer (Stags) sometimes become very vicious in the breeding season, and Bartlett says it is advisable to cut off the antlers of such males as soon as they become hard, in order to prevent them from injuring the females. I have not yet tried this, but we have from time to time lost female Deer through the savage nature of the Stag, which had injured the hind so badly that she either died from the effects of the injury or had to be destroyed. Fortunately such instances have been rare in the Pretoria Zoological Gardens; but here, again, my former assertion holds good, *viz.*, that one has to know the nature of each individual animal. Some years ago we had a Sambur Deer Stag so vicious that he had to be destroyed. At present the Gardens contain three stags of this species, and they are the most sociable of animals. This applies to Red Deer and Rusa Deer Stags as well.

With reference to the Antelope, I have found Bushbuck and Wildebeest the most pugnacious of animals in captivity, but even amongst these animals an occasional ram will be quiet and friendly. We had several bull Wildebeests and ram Bushbucks which injured several females in succession, so that they had to be left without mates, but at present the collection contains males of both species that live amicably with their mates. The first Lechwe ram we possessed was an absolute terror, and had to be shut up in his night-house before the camp could be swept,

but the animal at present in the collection takes no notice of any one going into his camp, or merely moves further away from the intruder. The same applies to two Eland bulls that we had, the vicious one of which is now dead, but the quiet animal is still in the collection. In captivity, an animal will sometimes, if given a fair opportunity, revert to its usual habits when in the wild state, as, for instance, several of the Deer, and more particularly the Lechwe Antelope. These animals were formerly in camps, which admitted of the egress of the young ones. The latter would go out of the camp after their morning drink and lie hidden in some hedge or flower bed in the vicinity until sunset, when the time for the evening meal came round, and then the little one would return to its mother.

In 1910 we possessed a pair of Gemsbuck, which were ultimately the proud parents of two young ones in 1911 and 1912. All these buck were tame and quiet, the ram to such an extent, that he preferred standing up to his attendants to giving way. He eventually became dangerous. All these died or were sold, and a fresh stock obtained from the Kalahari. This second lot of three, although hand-reared like the first, never became quite tame, and remained so shy and wild that when nearly full grown they came to grief by getting a fright and dashing into the iron fence of their camp, badly injuring themselves.

Zebras.—Zebras are just as subject to individual variation of temperament as the other animals mentioned. Some are easily tamed, and can be ridden and driven without fear or risk. Others again are vicious, and kick and bite without provocation. They are thus with their own kind as well as with the human race. We have at present two Zebra mares of two distinct species, which will not tolerate another animal of their own kind in either of their paddocks, not even of the opposite sex, biting and kicking with anything but friendly intentions. On the whole, though, Zebras are, both in the wild state and in captivity, sociable animals, loving company.

To finish up, let me quote a paragraph from Carl Hagenbeck's book, "Beasts and Men," which puts into a nutshell much of what I have tried to make clear in the foregoing pages:—

> There is no universal rule for the treatment of wild animals. Even individuals of the same species, so great is their variability of temperament, have to be managed according to the particular circumstances of each case. The peculiarity is found, as my narrative has already shown, among Elephants. It exists, in a greater or less degree, among all animals, and is a feature in his profession which no successful trainer can overlook. Moreover, it is difficult to foresee how animals will behave under any given circumstances, for they are swayed almost completely by the impulses of the moment, and it frequently happens that an occurrence to us apparently trifling will cause a perfectly quiet and well-behaved animal to become almost mad with terror.

AFRICAN NATIVE MELODIES.

By Rev. W. A. Norton, B.A., B.Litt.

I had the privilege of reading a paper on this subject before the South African Association for the Advancement of Science, at its meeting at Bloemfontein in 1909.* On that occasion I merely discussed the question in general, mentioning some of the material which I had at hand to prove my points. I have long been wanting to publish the songs I have at various times collected, but have waited until now, partly from want of leisure, partly hoping that someone more adept musically than myself might do the work better. But time is going on, and every year I find that native custom and language become more and more corrupt, and the true old African ring more and more obliterated by the flood of foreign modes. I feel, therefore, that no time is to be lost. If the ideal musicianly student of native arts arrives, my own work *may* be of use to him—at any rate, it will be no drawback. If he does not arrive, there will be some record of what is passed away. How glad we should be to find remains, however imperfect, of the music of our heathen Teutonic ancestors, or even of the Keltic or pre-Aryan tribes which preceded them! Even so I venture to think that the Africander of the future, and still more the Bantu of the future, will be glad of some records such as these, and if someone can correct these, where they may very well be astray, I shall only be too thankful.

But here let me utter a warning. Primitive Bantu music, as Professor Meinhof and other workers have pointed out, depends not on the melody, which is often poor, and to our ears often unpleasing, but on *rhythm*, which explains why the Suto word for a circumcision song corresponds with the Swahili word for a drum, the meaning apparently in original Bantu also; and why the Sechwana word for a hymn *se-opelo*, is from the verb *opa*, originally meaning to clap, or beat a drum. Bantu music is pre-eminently percussive, as some of us may have found to our cost when wanting to sleep o' nights, without realising the extremely elaborate character, artistic after its kind (if properly performed), of what we may call the "drumnody." The amateur pianist or songster, the "musical person" in the vulgar sense, is apt to ignore the art of drumming, as understood in military music, and used with such effect with the organ in funeral marches, etc. It is natural, therefore, for those who are narrow-minded enough to suppose that no good thing, artistic or otherwise, can come out of the African native, to miss the artistry of native rhythm. Those who have seen a really good war-dance at the mines, for example—the opportunity is rare elsewhere in the Union—or heard a good Chopi piano per-

* Rept. S.A.A.A.S., Bloemfontein (1909), 314-316.

formance, with the resounding gourd-zither, will, if they have ears for rhythm, have gained some experience of its intricacy; but even the humble lullaby (like No. 12 below), which may be heard in the backyard, will be found often quite a problem to unravel. Indeed, had I possessed a rhythmometer, such as is now used by ethnological students, I should have been inclined to confine myself to rhythm; but as my unaided ear was quite inadequate to the task of rhythm-record, I have fallen back on melody, which will, in conjunction with the rhythm of the Bantu words, sufficiently indicate, I hope, the beat. I have confined myself to melody, and this has the advantage of bringing out the scale and essential characteristics of the air, and avoiding the intricacies of harmonisation, which would have been within the reach of musicians only, and probably but few of them, *not* including myself.

Another point of warning: my experience is that if you hear the same song from several different groups, not only the harmonies, but the melodies, not to say the detail of the words, may be different each time, though the rhythm will probably remain constant. This illustrates what I have said above. The difference will often be due to different "parts" being really independent melody, as in counterpoint; but it is, of course, a commonplace of folk-song, as anyone who has studied the history of our older European melodies will acknowledge.

Permit me to refer those interested to my paper of 1909, published in the Bloemfontein Report, for the more general treatment, and let me recall that I had come, even then, to the conclusion that the Bantu* scale was probably the Pentatonic or Scotch.

I will give the melody of "Auld Robin Gray," or rather the melody, in the old Third mode, ending on **m**, to which Lady Nairn wrote, as I understand, the words of that familiar song, now, however, generally published to another and (I should say) later tune:—

m s d' l s m r d r d r m l
My father couldna work, and my mother couldna spin.
s l d' l s fm r d r d r m d'
I toiled day and night, but their bread I couldna win.
r' m' r' d' l s m' r' d'l s m r
Auld Rob maintained them baith, and with tears in his ee,
ms l d' l s m d' r' m' mf m
Said, "Jenny, for their sakes, wilt thou marry me?"

* Maybe even beyond their sphere in South Africa. An interesting book on American Negro melodies, whose author I forget, gives at least four pentatonic in a collection of 15 or 20: one especially interesting, with words handed down from the singer's grandfather's grandmother, who came as a heathen slave from Africa about 1700. Booker Washington's "Souls of Black Folk" gives some "sorrow songs" of Afro-Americans, of which two at least are pentatonic.

Except for the passing **f** in line 2, and the lift **mf** at the end, it will be seen that the scale runs: $\mathbf{m}^{1}$ $\mathbf{r}^{1}$ $\mathbf{d}^{1}$ **l s m**.

Let me take another example from the extreme East, from the other extremity of Eurasia, namely, from Corea, whence a friend was kind enough to procure me the following Pentatonic melody, a Confucian chant:—

$\mathbf{l}_{1}$, d r , m : d , r m , m s , m : m l , s m , r : m , s m , dr , d
$\mathbf{l}_{1}$, d r , m : d , r m , m s , m .

It will be noted that this scale, so frequent in the corners of the earth (it is used in China also), has no interval smaller than a tone; the only other interval between adjacent notes is the minor third; the semitone does not exist. Hence the fact, so often a trouble to missionaries here, that they cannot get semitones properly sung.

I will now proceed to Suto melodies, that being the Bantu language I am most familiar with, carefully observing any cases which do not conform to the Scotch scale above:—

d r m rd $\mathbf{l}_{1}$ $\mathbf{l}_{1}$ rd $\mathbf{l}_{1}$ $\mathbf{s}_{1}$ $\mathbf{s}_{1}$
1. (Ue) Ue, Ue maloto, *Khoashi* (2); hulele, *Khoashi* (2).

I have this song entered as a threshing song, but it is also used in a children's game with stones. They sit round, holding them, tap on the ground at the three "*Ue's*" and the syllable *lo,* and pass at the syllables in italics. The song is probably old, and the sense of the words lost. *Hulele* means "draw to" one; some read *Helele,* which is an interjection of surprise, and *Khaze.* *Z* does not occur in Suto. It is a question whether these alternatives are corruptions, or original, derived from some other dialect and corrupted into the mere Suto forms first given.

2. **m r m r** | **m mr** | **m r**
Seotsanyana Ha a robale, | *Ka sakanéng** | *La manyamane*
does not sleep | in the kraal | of the calves

m r | **m r d r $\mathbf{l}_{1}$**
Oa qethoha | *O etsisa Nkhekhenene*
he just lies on his back | **r d $\mathbf{l}_{1}$ d $\mathbf{s}_{1}$**
| he pretends sleep.

(The last line is sung twice, first to the melody above it, then to that below it.) Seotsanyana is a kind of Lob-lie-by-the-fire of the Basuto children. He does not lie on his side, like one really tired, but idly lolls on his back.

3. **r d $\mathbf{l}_{1}$ $\mathbf{s}_{1}$**

Ha ke hlole	ke bapala	I no longer play
Ke se ngoana e	monye-nyane	I'm not a little child:
Kulu-pana,	Kulu-pana!	Wallow, roll on the ground!

* The accent of the native words is on the penultimate syllable unless otherwise marked.

This seems to be a girls' *Khiba* song (a kind of heathen knee-drill). The last line seems to show that, though growing up, they have not yet put away childish things, and suggests with some humour the psychology of adolescence. A friend's collection gives a Suto threshing song, of which the melody of the second member of the couplet corresponds to this; the former member being the same, one note higher, and still in the Pentatonic scale.

d $s_{|}$ r d ($l_{|}$) $s_{|}$ r d $l_{|}$ $s_{|}$

4. Likoche: ha ho sechaba se hlolang makhooa! (*cf.* No. 3 for cadence).

i.e. "The Scotch! There is no nation which conquers the white men." I am not sure which war's experience this represents. I think I was told the last, but it would probably be true of all as regards the kilted Scots. The natives have a saying that they dress like women, but fight like men. (I might mention that I am in no wise Scotch myself.) From the African character of the tune, I should say that it was either an old tune adapted to these modern words, or else represents the experience of one of the earlier wars.

m r d

5. *Hele, Saole!* (*E be e le Saole.* "Perhaps it is Saole.")

m r d $l_{|}$ $s_{|}$ $m_{|}$ $l_{|}$d

O ba a e-ea kae Saole Hii "Where is Saole going?
O na lekola, a (le) le raretsa. "He has a crest which he draggles."
O ba . . . . Hii (as before).

This is a running song, going with the regulation war "double" of a native *impi*, which is imitated in the war dance. The legend says that Saole was raiding cattle for his marriage, but was caught in a pass and stoned. Native Christians curiously connect it with Saul on the Damascus road. The song is said to be very old, at least before horses became known in the thirties of last century; probably much older.

s r s m r d $l_{|}$ $s_{|}$

6. He, moloi! Tlhaka; A - - - - - -
ua e sollisa (re fihla. Mankiane h'a e-ea mo sollisa). He, Moloi! sss. . . Tlhaka.

The puzzle is *sollisa* *Sôla* is to cause a rash.
Sola is to throw off hair (moult) or skin (slough).
Solla is to wander, perhaps connected with the first, in regard to a rash changing place.
Sollisa is the causative; *Tlhaka* being a scar, either of the meanings seems possible.

"Hey, wizard! that scar, you *sollisa* it; (we are come. He has not *sollisa'd* Mankiane.)" The part in brackets does not always occur, and may be an addition. The woman Mankiane, wife of Mateka, one of Masopha's men, was said to be in Ladybrand not long ago after the rinderpest, so that part of the song cannot be very old. The hiss probably represents the pain, or spurt of blood, during the operation *phatsa*, inoculation against witchcraft.

m d r d **m** **d** **l_1** **s_1**
7. *Makopane* (e! Oei! Ahe!) *Ngoana u bone mathula*-ka-hloho.
m md rd mrd
Ahé, a-hé. . Child, see the things knocking their heads together.

Kopana is to embrace: *Makopane* is the *Mathula-ka-hlolo*, the Punch and Judy kind of doll (*modula*), enormous, with a rag head and a feather crest. Two of these are knocked together, and then embrace, as in our folk-drama. I cannot fix the tune of the former nonsense words, probably a variation of the latter.

Hitherto our tunes have ended on **s** in the Pentatonic scale, having the single tone above the final: **m r d l_1 s_1** This song, however, has the double tone above the final, *viz.*, **l s m r d,** and so corresponds so far with our major mode. The following appears to be similar.

m r m **r d r** **l_1 d s_1** **r l_1 d**
8. (He!) leqhekoanyana, lea bua; le 'na, ke bue: hole le Sankoe,
s m **d r d s m d**

s_1 r d s_1 m_1
hoi hoi! hoi! ho Sankonini.

m r d l_1 s_1
(and also lea bua; le 'na, ke bue as a variation of the upper tune).

Hey! the little old man, he speaks: let *me* speak.

Here, *hole le Sankoe* may mean "far from Sankoe," apparently a place, possibly the speaker's home: *ho Sankonini*, on the other hand, means to a person of that name. These two names do not seem to be Suto: *leqheku also*, the diminutive of which begins the song, is the Zulu-Kafir *ixegu*, probably derived in its turn from Hottentot, like most clicked words. This dramatic little song is said to be fairly recent. I have included all my variations of tune as well as words, as they illustrate my preface.

m r d **m r d** **m r** **d** **d** **m** **r d** **m**
9. *Maribane* *O ribile* *A nts'a* *ts'oana*: *ts'oana* *li* *'mele* *li*
nutat *extrudens* *album*: *alba* *sunt corpora*

r d
mekatako (*multitudines*).

From the simplicity of the tune, and matter-of-fact mystery of the words, I regard this as very old, probably a circumcision song. *Riba,* is to nod up and down (*leriba* is the straw visor of the *bale* (girls undergoing puberty rites). *Maribane* possibly corresponds to Priapus among the Greeks; in which case the song will be in some sense phallic. I have discovered very few of this sort; the ordinary songs seem quite remarkably free from what one would have expected from primitive peoples.

We now come to tunes ending on the third above or below the keynote, and thus correspond roughly to our minor mode. The scale in this case will stand: **r d l$_{|}$ s$_{|}$ m$_{|}$**
or **s m r d l$_{|}$**
The second note shows the difference between the two forms. The remaining tonality: **d$^{|}$ l s m r** does not seem to occur, apart from **m r d l$_{|}$ s$_{|}$** , which we have already dealt with (Nos, 1-4). No. 13 represents the former of the two alternatives above, and Nos. 10-12 the latter.

md md m (f) r d r l$_{|}$
10. *Ua, Ua, Tsam'o bitsa Morena Tlake* (2).
Go, call the King Vulture d t$_{|}$ r d

sm s f d f m
Ua! A tl'o phunya malana, re je. (2).
Let him come pierce the maw, that we may eat.

m r d l$_{|}$ t$_{|}$ d
Ntja e shoele le kokotoana. (2).
The dog is dead, his skin is dry.

This grim ditty, racy of the soil, interests me not only for the dash of rude poetry which pictures the crows with their "Ua, Ua," calling their royal cousin, the great aasvogel, to the feast they may not begin alone. But for this reason: the tune was first given me in the second form, and seemed to me curiously European; it was only the other day that I heard the form which I have put at the top, and which is Pentatonic, and I believe original, or more nearly so. The third form is simply a variation to harmonise with the second, as I imagine, and probably the last also.

s l s m r d sm r d (l$_{|}$)
11*. Mabele a oroha (2) re ee hae; Ohá (2) ha bots'oene.
The millet is going home, let us go home where the monkeys are.

This is a harvest home song. *Ohá* is the monkeys' cry. I thought at first that the tune ended on **d,** but now have discovered a slight drop on the last syllable. We are using this tune in more than one language for a harvest hymn, and it is a

* *Cf.* M. Junod's "Sailor's song on the Nkomati River": **ls, ls, mrdd, ls.**

great favourite. The first half easily adapts itself to Christian use, thus:

The corn goes home: The souls go home: Great is the harvest: The Chief will be there at the Feast: and will give His wages

Needless to say, the final words have to be altered. Personally, I think it a great pity that English hymn-tunes and translations of English hymns have been used for the natives. Both are often very poor, and the tunes entirely unsuitable in rhythm. The difficulty of unsuitable *association* is readily got over by giving Basuto a Swahili melody, and *vice versa*, and so on. If we were squeamish about origins or forgotten associations, we should miss some very fine folk-melodies, which appear as modern English hymn-tunes.

r lsm **r lsl,**
12. E . . I . . *Uena nana* (or *ngoana*) E . . I . . Baby:
. . . . *ke u pepile*: E . . I . . I have carried you.
. . . . *ka lithatsana* . . . . . . In the little *lithari*.
. . . . *tsa-bommae* . . . . . . Of your mothers.

There is something very touching in this lullaby. It is long, very long, since I was sung to sleep with:

> "Rockaby baby on the tree top:
> When the wind blows the cradle will rock,"

but I seem to recognise the same tossing lilt in both. The native mother is, after all, radically of the same stock as the European, but with a difference, at any rate in externals. Thus *pepa* is to carry on the back in the *thari*, or sheepskin. The song seems to represent the rocking and tossing the child must get, as the mother raises and lowers her hoe at the field work.

I should say that I am beholden to Dr. Frere, of Mirfield, a distinguished European scholar and musician, who was good enough to record Nos. 5, 4, 12, and 16 for me when on a visit once to Modderpoort.

(1) s m r d l, m rd r
13. (Se)phoko se linaka, thaka tsa me . . kuankuantsilo' ! ho

s s m
ntsoe mane !
The horned owl, my mate . . . . . . let
it out over there.

Whether the word untranslated represents the owl's hoot, or is a name, I cannot tell: the piece is a *lengae*. *Mangae* (pl.) are odes sung in the intervals of the *lithoko*, the praises acclaiming a chief. Some of these are of real poetic value, but do not concern us here, as (anciently, at any rate) they were not sung, but recited. The *mangae* are, as it were, the choruses of a Greek play, or rather the lyrics which give variety to an epic

poem, since the *lithoko*, though often highly dramatic, are not in dialogue form. To illustrate, however, the whole primitive art-form, let me give an example which I have just discovered among old hoards: it is doubtless corrupt, but will give an idea of the real sense of composition which the native poets enjoyed:

A : *sephoko se linko tsa Takatsane*. B : Ho *ntsoe mane* (constant refrain)

Ho...ho...ho... (B)

i. *Ekare ha ke etela Thaba* Putsoa (B) ba nkalima e *Putsoa pelesane* (B)

ii. .... Patsoa (B) C : Ho ntsue *lele ntsue lele* (B)
ba nkalima e *Patsoa pelesane*
(A, B, C, B)

iii .... Chicha (B) ....*Chicha*...............(B, C)

iv. .... Nts'o ....*Nts o*.............. ...

v. *Lipere tsa MaEngesemane bokuebu !*

Chorus : *Kuankuantsilo'* (constantly repeated).

The first line is probably a corruption of the lengae above (No. 13). It would mean, literally, "Owl with the nose of T."

Line i. is:

When I visited the Blaauwberg, they lent me a blue little beast of burden.
ii. : .... Dappled Mountain, ...dappled.........

. . . , and so with iii. and iv., where *Chicha* is "round" and *Nts'o* "black." v. reads: The horses of the Englishmen are *bo-kuebu* (said to mean "roan"). As regards the geography, Thaba Patsoa is a mountain to the south of the line between Westminster and *Thaba 'Nchu*. (Harrismith is also the *Black Mountain.*) Thaba Chicha is a conical hill on a quadangular base between Modderpoort and Clocolan, also in the Orange Free State. But what is a *Chicha* pelesane? A *round ox* is one with no horns. A round *horse* is presumably a fat one, but the former translation seems more likely.

If our specimen is anything near 100 years old, the pelesa (beast of burden) *must* be a pack-ox, and line v. a later addition. When horses were first seen with their pale riders, they were taken for ghost cattle, which traditionally have no horns.

The poem has omitted an important point: were the cattle lent ever returned?

These are nearly all the Suto songs to which I have anything like complete notation. The others are interesting as poetry, but must wait for another time. I will pass on, therefore, to the allied Serolong, inserting, however, first, a Suto scrap in the Scotch scale, which suggests the lilt and tonality of the Chwana No. 15.

s$_{|}$ d d d r s m d md r d d

14. *Mabele!* (3) *na lea tseba a lengoa joang mabele?*
Kafircorn! Know ye how Kafircorn is hoed.

s l s m d r d d l$_{|}$ d m d m d r d

15. *Thibelele* (2) *Rakocha: Ai shi shi. Ai shi, O Rakocha.*
Make a circle..................

s m s   m r d   d l_1 d m   d m d r d
Ea Moroka (2) *ea loana. E loana ka, e loana ka lithopi* (2).
The (Army) of M, is fighting .... with guns!
s l s m d r d   d l_1 d
Khomo li ya seboku. Ai shi shi......
The oxen are eating the grass ....

This is a threshing song of the Barolong of Moroka, who migrated to Thaba 'Nchu from Bechuanaland in the thirties, and assisted the Boers against the Basuto, who claimed to be over-lords of the Barolong: hence the guns.

Dudley Kidd gives a Gazaland song something like this, and in the same scale; No. 17, though Setebele, also recalls the melody theme.

s_1 s_1d m r d r d r d r d l_1
16. *U'lelang? Oabo mago a timana a tima babelegi* (?)

What are you crying for? Were your mother's people stingy with the nurse-girls?

There is a version of this added on to the words of the Suto lullaby, No. 12. It continues:

. . . *'Mae a timana nama le bohobe*	His (that is the child's) mother stints meat and bread. (It is the nurse-girl that speaks.)
Ha ke mo pepile	When I carry him
Ntat'ae a timana sixpence.	His father stints 6d. Ay, ee!
Tsela nka ea ka efe?	I can go by Maseru.
Nka ea ka Maseru.	Which way can I go?

The sixpence reveals modernity, and probably the European nationality of the child. Well, it is good to see ourselves as others see us; but I wonder if the nurse-girl had given notice according to law. The language in this case is Suto.

Let us now pass to Setebele. The following is a war-song:

m r d d r d l_1 d_1 r_1
17. *Abamodandi bonke bati: Makwenkweshane, siyakufa.*

The men of Modandi all are saying: Mak. (name of the singer's tribe) we are dying.

r d l_1 s_1 m_1 d_1 d_1 s_1 m_1 s m d l_1 d
Yinina? Sibaqede. Oyayo. Oyayo. Hambe ke!

Wherefore so? We have finished them. . . . . Then march away!

M. Junod gives a Ronga tune of similar wide compass, which I venture to transpose to shew its Pentatonic character:

s m m
m r r r d l_1
s_1 l_1 l_1 s_1 m_1
s_1 m_1 s_1

Now all these South African tunes are in the Pentatonic or Scotch scale in one or other of their forms. I have found rarely

any (but those frankly modern) which did not correspond to this scale, among the Suto and Chwana tribes. Also among the Bondei of East Africa I found the following: **s m d r s_1**, then **d d^1 s d^1**, then **d^1 l d^1 l s l**, but I confess that others of that part were otherwise. Also all but one of Father Torrend's collection, and all but one, I think, of the Zulu tunes of Father Mayr, whose sad death lovers of native lore must deplore. I found one Pentatonic only, but that a lullaby, and therefore probably old, among those Baroness Posse so carefully collected, and allowed me to exhibit with my last musical paper. None of the native pianos I have tried are confined to the Scotch scale; a Zulu Zanze, which I had tried or seen quoted somewhere, gives **d^1 l s m r d l_1 s_1 f_1** (!) **m_1**. All but the penultimate note are in the Scotch scale.

A *setolotolo*, however, gives **d r d s_1** and a *lesiba*, **m m s m m d : r m r d**. Other pentatonic scraps my ear has caught are in Suto **d^1 s l s m** a threshing song; **s m s m r** a dance tune; **d^1 r^1 d^1 l : s m r : s d s** heard at Tsikoane in Leribe; **d^1 r^1 d^1 l, f s l : sl s m d r d** I heard somewhere. The second is practically the former pentatonic phrase transposed a 4th.

Examples of *Modern Native Tunes* (in the modern scale) by way of contrast:

s m r d d,   **r d l_1 s_1 s_1**
1. Ai-ko-na white man.   Ai-ko-na black man.
Whether it's a white man.   Whether it's a black man.

d r f s f r m d
Mi-na hambi-le fu-na skof
One's going round to look for skof !

d r m f s m f r s s s s
2. Siya ku bo-na Sonke kahle bitje-nya-na
We shall all be glad to get a little bit.

Hla-la la-pa pan-si ma-si-hambe.
Sit here on the floor......let us go!

s d^1 t l s m m m f s :- r r r
3. Mosali Mo-ho-lo O'nti-mi-le jua-la nti-mi-le

mf r d d d t_1 d
Jua-la nti-mi-le jua-la

d m l s m m m f s r r r
Sti-ma sti-ma sti-ma-na jua-la sti-ma-na

m fmr d d d t_1 d
jua-la sti-ma-na jua-la
i.e.—The old lady has stinted me of beer...... Oh don't do that! *Stima* is presumably for *se time* don't stint.

m r m f m r m f m r d r d
4. Ha le se le ka Paradeiseng: Oho m'nyako 'a Adam le Eva.
(sa?)
When you were still in Paradise. Oh! the gate of Adam and Eve !

ON THE GAMMA, OR FACTORIAL, FUNCTION.

By Prof. W. N. ROSEVEARE, M.A.

Summary of Paper.

THE Binomial Coefficient which can be written $\frac{n\,!}{(n-i)\,!\,i\,!}$ when n is a positive integer, cannot be reduced to this simple form when n is more general, unless we can devise a meaning for $n\,!$ for other values of n. The continuous function so defined is known variously as the Gamma Function or Gauss' Function. I prefer to call it the Factorial Function and to represent it in Gauss' notation by Πn. The general binomial coefficient I denote by $(n)_i$, extending the symbol $(n)_a$ to represent the generalized $\frac{\Pi n}{\Pi(n-a)\,.\,\Pi a}$, where n, a have any values.

In this paper I have attempted, first, to give a series of connected proofs of the main theorems.

Proposition I.—On the existence of the function.
(Excursus on 'a fair curve' and 'simple' functions.)

" II.—That Gauss' function is the unique 'simple' function which generalizes $i\,!$.

" III.—A complete analytical expression for $e^x\Pi x/x^{x+\frac{1}{2}}$.

" IV.—Connection between Πx and $\Pi(-x)$.

" V.—$n^{nx}\,.\,\Pi x\,.\,\Pi\left(x-\frac{1}{n}\right)\Pi\left(x-\frac{2}{n}\right)\ldots\Pi\left(x-\frac{n-1}{n}\right)\Big/\Pi(nx)$.

" VI.—The Factorial Function as Euler's Second Integral $\int_0^1\left(\log\frac{1}{\theta}\right)^x dx$.

" VII.—$\int_0^1 \theta^x(1-\theta)^y d\theta=\frac{\Pi x\,\Pi y}{\Pi(x+y+1)}$ when finite (two proofs).

" VIII.—Expansion of $\log \Pi x$ and Πx in power series.

" IX.—Fundamental proof that Πx can be expanded in powers of x when $|x| < 1$.

Proposition X.—$(n)_a = \frac{1}{2\pi\iota}\int z^{-a-1}(1+z)^n dz$ round the unit circle if $n > -1$ and a has any value.

Propositions resulting from the above (proofs not given) on extended Binomial formulæ and Fractional differentiation, with applications to Hypergeometric series and fractional spherical harmonics.

The Propositions, though forming, it is hoped, a continuous whole, are not to any great extent interdependent. Some proofs are old established : some are new.

The ordinary factorial of a positive integer is fully defined by the relation $n! = n(n-1)!$, with the special value $0! = 1$.

If we had a meaning for $x!$ when x is not a positive integer, many algebraical formulæ, especially the binomial coefficient, could be simplified. We proceed to discuss whether there is a simple extension of $n!$ to the general case. The conclusion to which we shall come is as follows :

PROPOSITION I.

If Πx is a function satisfying the relation $\Pi x = x\Pi(x-1)$, and equal to $x!$ when x is a positive integer, then there is an infinite variety of possible forms of Πx, but one special form which may be described as the 'simple' form.

The relation $\Pi x = x\Pi(x-1)$ leads of course to

$$\Pi x = \frac{\Pi(x+N)}{(x+1)(x+2)\ldots(x+N)}$$

where N is a positive integer. And if $\Pi(x+N)$ can be determined when $N \longrightarrow \infty$ the definition of Πx is complete.

Now if x is a positive integer

$$\Pi(N+x) = (N+x)(N+x-1)\ldots(N+1)\Pi N$$

which* $$< \Pi N \left| \begin{matrix} (N+1)^x \\ (N+x)^x \end{matrix} \right| < \Pi N \,.\, N^x \left| \begin{matrix} \left(1+\frac{1}{N}\right)^x \\ \left(1+\frac{x}{N}\right)^x \end{matrix} \right|$$

therefore, when x is a positive integer, $\frac{\Pi(N+x)}{N^x \Pi N} \longrightarrow 1$.

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* The notation $u < \left|\begin{matrix} a \\ b \end{matrix}\right|$ is used throughout this paper to mean 'u lies between a and b.' Where possible the upper symbol a is reserved for the greater limit. The notation is then equivalent to $a > u > b$. It will be seen that the inequality admits of all the transformations of an equation.

We may now assume this relation to hold when x is general: and so obtain $\Pi x = Lt. \dfrac{N^x \Pi N}{(x+1)\dots(x+N)}$ as the definition of a possible Factorial Function. This formula was established by Gauss, and the function is known as Gauss'.

Excursus on what we propose to call 'simple' functions.*

It is known that if a_1/b_1, a_2/b_2, a_3/b_3, ... are fractions whose *denominators* are all positive, then $\Sigma a/\Sigma b$ lies in value among the given fractions.

It is also true that if a_1/b_1, a_2/b_2, ... are in ascending order, $\Sigma_n a/\Sigma_n b$, by which we mean $(a_1+a_2+\dots a_n)/(b_1+b_2+\dots b_n)$ increases *with* n: for $\Sigma_n a/\Sigma_n b = (\Sigma_{n-1}a + a_n)/(\Sigma_{n-1}b + b_n)$, which lies between $\Sigma_{n-1}a/\Sigma_{n-1}b$ and a_n/b_n: but $\Sigma_{n-1}a/\Sigma_{n-1}b$ lies between a_1/b_1 and a_{n-1}/b_{n-1} and is therefore less than a_n/b_n.

Hence
$$\frac{\Sigma_n a}{\Sigma_n b} > \frac{\Sigma_{n-1}a}{\Sigma_{n-1}b}.$$

Moreover, if $\Sigma_n a_i$ means the sum of n terms beginning with a_i, $\Sigma_n a_i/\Sigma_n b_i$ increases with i, when n is constant.

For, $\Sigma_n a_i/\Sigma_n b_i = (a_i + \Sigma_{n-1}a_{i+1})/(b_i + \Sigma_{n-1}b_{i+1})$, which lies between a_i/b_i and $\Sigma_{n-1}a_{i+1}/\Sigma_{n-1}b_{i+1}$, whereas

$$\frac{\Sigma_n a_{i+1}}{\Sigma_n b_{i+1}} = \frac{\Sigma_{n-1}a_{i+1} + a_{i+n}}{\Sigma_{n-1}b_{i+1} + b_{i+n}}$$

lies between $\Sigma_{n-1}a_{i+1}/\Sigma_{n-1}b_{i+1}$ and a_{i+n}/b_{i+n}, therefore the latter is the greater.

Hence $\Sigma_n a_i/\Sigma_n b_i$ increases with i when n is constant.

Applying these results to the series of fractions

$$\frac{fx_1 - fx}{x_1 - x}, \ \frac{fx_2 - fx_1}{x_2 - x_1}, \ \dots,$$

where x, x_1, x_2 ... are increasing values of a variable, we find that if these fractions are in ascending order, $(fX - fx)/(X - x)$ increases with X when x is constant, and $(f(x+\delta x) - fx)/\delta x$ increases with x when δx is constant.

These results hold if the intervals between x, x_1, x_2 ... are indefinitely diminished, in which case the set of fractions becomes $f'x$, $f'x_1$, $f'x_2$, ... Corresponding results hold, of course, if the original fractions are in *descending* order. Hence, if fx is a continuous function of x such that $f'(x)$ continually increases or diminishes throughout a certain range of x (i.e. if $f''(x)$ is positive or negative throughout the range).

* The word 'simple' is used elsewhere of functions considered simple from other points of view: it is therefore impossible to stereotype the word as used in this paper.

$$\text{(I).}\quad \frac{fX-fx}{X-x} < \left|\begin{matrix} f'X \\ f'x \end{matrix}\right| \text{ and } \therefore f'x < \left|\begin{matrix} \dfrac{fX-fx}{X-x} \\ \dfrac{fx-f\xi}{x-\xi} \end{matrix}\right| \text{ if } X>x \text{ and } \xi<x.$$

II. $\dfrac{f(x+\delta x)-fx}{\delta x}$ increases (or diminishes) as δx increases, when x is constant.

III. $\dfrac{f(x+\delta x)-fx}{\delta x}$ increases (or diminishes) as x increases, when δx is constant.

A function for which $f''(x)$ is always positive or always negative we propose to call a 'simple' function.

The more familiar types of continuous functions consist of a succession of 'simple' functions: in other words, they may be represented by curves with only occasional points of inflexion.

A useful application of (I) is to the approximate summation of series whose terms are of the form $f'(x)$.

$$\text{Thus,}\quad \sum_{x=\xi}^{x=X} f'x \,.\, \delta x, \text{ when } \delta x \text{ is constant, } < \begin{matrix} f(X+\delta x)-f\xi \\ fX-f(\xi-\delta\xi) \end{matrix}$$

$$\text{e.g.}\quad \sum_{i=0}^{i=n} \frac{1}{(a+i)^2} < \left|\begin{matrix} \dfrac{1}{a} - \dfrac{1}{a+n+1} \\ \dfrac{1}{a-1} - \dfrac{1}{a+n} \end{matrix}\right|$$

The 'summation theorem' of Integral Calculus is a special case.

By means of II and III we will now prove Proposition II, that Gauss' assumption, in regard to the factorial function, that $\Pi(N+x) \longrightarrow N^x . \Pi x$ is the only assumption which makes $\log \Pi x$ a 'simple' function (from $x=-1$ to $x=\infty$).

PROPOSITION II.

We have $fx = \dfrac{f(x+N)}{(x+1)\ldots(x+N)}$, and for positive integral values of x, fx is the ordinary factorial, x!

$$\text{Since}\qquad \log f(x+1)-\log fx = \log(x+1),$$

$\log f$, if 'simple,' must be an *increasing* function.

Considering x to vary only from 0 to 1 and using N for a positive integer,

$$\frac{\log f(N+x)-\log f(N)}{x},$$

$$\text{by II and III above,} < \left| \begin{matrix} \log f(N+1)-\log fN \\ \log f(N+x)-\log f(N+x-1) \end{matrix} \right|$$

$$\text{i.e.} \quad < \left| \begin{matrix} \log (N+1) \\ \log (N+x) \end{matrix} \right| < {}^{*}\log N + \left| \begin{matrix} \dfrac{1}{N} \\ \dfrac{x}{N+x} \end{matrix} \right|$$

$$\therefore \quad \frac{f(N+x)}{N^x \,.\, fN} < \left| \begin{matrix} e^{x/N} \\ e^{x^2/(N+x)} \end{matrix} \right| \text{ and therefore} \longrightarrow 1 \text{ as } N \text{ increases.}$$

Hence, Gauss' Definition $\Pi x \equiv Lt \dfrac{N^x \,.\, \Pi N}{(x+1)(x+2)\ldots(x+N)}$ gives the only function with a 'simple' logarithm which satisfies the factorial law, and has $f(0) = 1$.

That other (not 'simple') functions satisfy the conditions is evident from the form $\Pi x \,.\, \{\cos 2x\pi + (\text{const.}) \sin 2x\pi\}$.

One aim of this theory of 'simple' functions is to reduce to logical order the somewhat nebulous ideas implied in the phrase 'drawing a *fair curve* through given points,' which one meets with in graphical work.

PROPOSITION III.

A complete analytical expression for Πx.

Since $\log \Pi(x+1) - \log \Pi x = \log (x+1)$,

$$\therefore \quad \{\log \Pi(x+1) - (x+1+a)\log (x+1)\}$$
$$= \{\log \Pi x - (x+a)\log (x+1)\} \; a \text{ arbitrary}$$
$$= \{\log \Pi x - (x+a)\log x\} - (x+a)\log \frac{x+1}{x}$$

$$\therefore \quad \log \frac{\Pi x}{x^{x+a}} - (\text{ditto } \overline{x+1}) = (x+a)\, Av^{\dagger} \frac{1}{x+\theta} = 1 + Av \frac{a-\theta}{x+\theta}$$
$$= 1 + Av^{\dagger} \frac{a-1+\theta}{x+1-\theta}$$

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* It follows at once from the definition of '*the* logarithm' that $\log x < \left| \begin{matrix} x-1 \\ 1-\dfrac{1}{x} \end{matrix} \right|$ $(x-1)$ being always the upper limit.

† '$Avf(\theta)$' is here and elsewhere used for $\int_0^1 f(\theta)d\theta$. The notation is less cumbersome, and the special result $Av\theta^n = 1/(n+1)$ is constantly useful in expansions (as here).

Expand the last fraction in powers of θ and carry out the integration (which is legitimate when $x > 0$), and then we get

$$\log \frac{e^x \Pi x}{x^{x+a}} - (\text{ditto in } \overline{x+1}) = \sum_0 \frac{1}{(x+1)^{i+1}} \left\{ \frac{a-1}{i+1} + \frac{1}{i+2} \right\}$$

$$= \sum_0 \frac{1}{(x+1)^{i+1}} \cdot \frac{ai+(2a-1)}{(i+1)(i+2)}.$$

Hence, taking $a = \frac{1}{2}$,

$$\log \frac{e^x \Pi x}{x^{x+\frac{1}{2}}} - (\text{ditto in } \overline{x+1}) = \sum_2 \frac{1}{(x+1)^i} \cdot \frac{i-1}{2i(i+1)}.$$

[This choice of a makes $\log e^x \Pi x / x^{x+a}$ converge most rapidly to a definite value when x is big.]

Writing down corresponding equations for values of x increasing by unity, and adding them up, we get

$$\log \frac{e^x \Pi x}{x^{x+\frac{1}{2}}} - \log \frac{e^{x+N} \Pi (x+N)}{(x+N)^{x+N+\frac{1}{2}}} = \sum_{n=1}^{N} \sum_{i=2} \cdot \frac{1}{(x+n)^i} \frac{i-1}{2i(i+1)}$$

and the second term on the left converges as N increases to

$$(x+N) + \log (N^x \Pi N) - (x+N+\tfrac{1}{2}) \log (x+N)$$

which $\longrightarrow x+N+x \log N + \log \Pi N - (x+N+\frac{1}{2}) (\log N + x/N)$

and this is independent of x, when $N \longrightarrow \infty$.

Let $\boldsymbol{L}$ be the limit of $e^N \Pi N / N^{N+\frac{1}{2}}$.

Then
$$\boldsymbol{L} = Lt \frac{e^N \Pi N}{N^{N+\frac{1}{2}}} = Lt \frac{e^{2N} \Pi (2N)}{(2N)^{2N+\frac{1}{2}}}$$

and so

$$\boldsymbol{L} = Lt \frac{(\Pi N)^2}{\Pi (2N)} \cdot \frac{(2N)^{2N+\frac{1}{2}}}{N^{2N+1}} = Lt \frac{2 \cdot 4 \ldots 2N}{1 \cdot 3 \ldots 2N-1} \cdot \sqrt{\left(\frac{2}{N}\right)}.$$

Now, since
$$\sin \frac{x\pi}{2} = \frac{x\pi}{2} \left(1 - \frac{x^2}{2^2}\right) \left(1 - \frac{x^2}{4^2}\right) \ldots,$$

we have Wallis's formula for π,

$$\frac{\pi}{2} = Lt \frac{2^2 \cdot 4^2 \ldots (2N)^2}{1 \cdot 3^2 \cdot 5^2 \ldots (2N-1)^2 \cdot (2N+1)}.$$

Hence
$$\sqrt{(2\pi)} = Lt \frac{2 \cdot 4 \ldots 2N}{1 \cdot 3 \ldots 2N-1} \cdot \sqrt{\left(\frac{4}{2N+1}\right)} = \boldsymbol{L}.$$

Hence $Lt\,\dfrac{e^N \Pi N}{N^{N+\frac{1}{2}}} = \sqrt{(2\pi)}$ (known variously as Stirling's or J. A. Serret's formula).

We now have (if $x>0$)

$$\log \frac{e^x \Pi x}{x^x \sqrt{(2\pi x)}} = \sum_{n=0}^{\infty} Av\, \frac{\frac{1}{2}-\theta}{x+n+\theta} = \sum_{n=1}^{\infty} \sum_{i=2} \frac{1}{(x+n)^i}\, \frac{i-1}{2i(i+1)}$$

The right-hand expression can also be transformed by using the relations :

$$Av\,\frac{\frac{1}{2}-\theta}{x+\theta} = \int_0^1 d\theta \frac{\frac{1}{2}-\theta}{x+\theta} = \int_0^1 d\theta \frac{\theta-\frac{1}{2}}{x+1-\theta} = \tfrac{1}{2}\int_0^1 d\theta \frac{(\frac{1}{2}-\theta)\{1-2\theta\}}{x^2+x+\theta-\theta^2}$$

$$= \int_0^1 d\theta \frac{(-\frac{1}{2}+\theta)^2}{(x+\frac{1}{2})^2-(\theta-\frac{1}{2})^2} = \int_{-1}^{1} \frac{d\theta}{2}\, \frac{\theta^2}{(2x+1)^2-\theta^2} = \int_0^1 \frac{\theta^2 d\theta}{(2x+1)^2-\theta^2}$$

and so
$$\log \frac{e^x \Pi x}{x^x \sqrt{(2\pi x)}} = \sum_{n=0}^{\infty} Av\,.\,\frac{\theta^2}{(2x+2n+1)^2-\theta^2}.$$

When x is big, this can be shown to lie between $1/6(2x+1)$ and $1/6(2x)$ (using former Propositions for 'simple' functions).

PROPOSITION IV.

Connection between Πx and $\Pi(-x)$.

$$\Pi x\,.\,\Pi(-x) = \text{by Gauss' Definition, } Lt\, \frac{\Pi N\,.\,\Pi N}{(x+1)\ldots(x+N)\;(-x+1)\ldots(-x+N)}$$

$$= Lt\, \frac{1}{\left(1+\frac{x}{1}\right)\ldots\left(1+\frac{x}{N}\right)\left(1-\frac{x}{1}\right)\ldots\left(1-\frac{x}{N}\right)} = Lt\, \frac{1}{\left(1-\frac{x^2}{1^2}\right)\left(1-\frac{x^2}{2^2}\right)\ldots\left(1-\frac{x^2}{N^2}\right)}$$

but
$$\sin x\pi \equiv Lt\, x\pi\left(1-\frac{x^2}{1^2}\right)\left(1-\frac{x^2}{2^2}\right)\ldots\left(1-\frac{x^2}{N^2}\right)$$

$$\therefore\quad \Pi x\,.\,\Pi(-x) = \frac{x\pi}{\sin x\pi}, \quad\text{or}\quad \Pi x\,.\,\Pi(-x-1) = \frac{-\pi}{\sin x\pi}$$

Hence also $\Pi(x+i) \,.\, \Pi(-x-i-1) = \dfrac{-\pi}{\sin(x+i)\pi} = (-)^i \cdot \dfrac{-\pi}{\sin x\pi}$

and in particular, putting $x = -\frac{1}{2}$,

$$\{\Pi(-\tfrac{1}{2})\}^2 = \pi, \quad \Pi(-\tfrac{1}{2}) = \sqrt{\pi}.$$

Introducing negative values of x in Proposition III,

$$\log \frac{e^x \Pi x}{x^x \sqrt{(2\pi x)}} \text{ becomes } \log \left(\frac{e^x}{x^x \sqrt{(2\pi x)} \,.\, \Pi(-x)} \cdot \frac{x\pi}{\sin x\pi} \right)$$

$$= \log \left(\frac{x^{-x} \sqrt{(2\pi x)}}{e^{-x}\Pi(-x)} \cdot \frac{1}{2 \sin x\pi} \right)$$

$$\therefore \quad \log \frac{e^{-x}\Pi(-x)}{x^{-x} \sqrt{(2\pi x)}} = \log (\tfrac{1}{2} \operatorname{cosec} x\pi) - \sum Av \frac{\theta^2}{(2x+2n+1)^2 - \theta^2}$$

PROPOSITION V.

To prove that $\dfrac{n^{nx} \,.\, \Pi x \,.\, \Pi\left(x - \frac{1}{n}\right) \,.\, \Pi\left(x - \frac{2}{n}\right) \cdots \Pi\left(x - \frac{n-1}{n}\right)}{\Pi(nx)}$ *(when n is a positive integer) is independent of x and* $= \dfrac{(2\pi)^{(n-1)/2}}{\sqrt{n}}$.

For $\Pi(nx) = Lt \dfrac{\Pi(nx+nN)}{(nx+1)(nx+2)\ldots(nx+Nn)}$

$$= Lt \frac{\Pi(nx+nN)}{n^{nN} \,.\, \left(x+\frac{1}{n}\right)\left(x+\frac{1}{n}+1\right)\cdots\left(x+\frac{1}{n}+N-1\right) \atop {\left(x+\frac{2}{n}\right)\left(x+1+\frac{2}{n}\right)\cdots\left(x+\frac{2}{n}+N-1\right) \atop {\cdots\cdots\cdots\cdots \atop (x+1)(x+2)\ldots(x+N)}}}$$

$$\text{which} \equiv Lt \frac{\Pi(nx+nN)}{n^{nN}} \cdot \frac{\Pi\left(x-\frac{1}{n}-1\right)}{\Pi\left(x+\frac{1}{n}-1+N\right)} \cdot \frac{\Pi\left(x+\frac{2}{n}-1\right)}{\Pi\left(x-\frac{2}{n}-1+N\right)} \cdots \frac{\Pi(x)}{\Pi(x+N)}$$

Now in the limit

$$\Pi(Nn+nx) = (Nx)^{nx} \,.\, \Pi(Nn) = (Nn)^{nx} \,.\, \sqrt{(2\pi)} \,.\, e^{-Nn}\,(Nn)^{Nn+\frac{1}{2}}$$

and in general, $\Pi(N+y) = N^y \,.\, \Pi N = N^y \,.\, \sqrt{(2\pi)} \,.\, e^{-N} \,.\, N^{N+\frac{1}{2}}$

$$\therefore \quad \frac{\Pi nx}{\Pi x \,.\, \Pi\left(x-\frac{1}{n}\right)\ldots\Pi\left(x-\frac{n-1}{n}\right)}$$

$$= Lt \,.\, \frac{(Nn)^{nx} \,.\, \sqrt{(2\pi)} \,.\, e^{-Nn} \,.\, (Nn)^{Nn+\frac{1}{2}}}{n^{nN} \,.\, \left\{N^{n(x-n-1/2n)}\left(\sqrt{(2\pi)} \,.\, e^{-N} \,.\, N^{N+\frac{1}{2}}\right)^n\right\}}$$

which $= \sqrt{(2\pi)}^{1-n} \,.\, \dfrac{N^{nx+Nn+\frac{1}{2}}}{N^{nx-n/2+\frac{1}{2}+Nn+n/2}} \,.\, \dfrac{n^{nx+Nn-\frac{1}{2}}}{n^{nN}} = \dfrac{n^{nx+\frac{1}{2}}}{\{\sqrt{(2\pi)}\}^{n-1}}$ Q.E.D.

Corollary.—If $x=0$, $\Pi\left(-\frac{1}{n}\right) . \Pi\left(-\frac{2}{n}\right) \ldots \Pi\left(-\frac{n-1}{n}\right) = \sqrt{\left(\frac{(2\pi)^{n-1}}{n}\right)}$

PROPOSITION VI.

The Factorial Function as 'Euler's Second Integral' or the 'Gamma Function.'

We have approached the Factorial Function from Gauss' point of view, which has the advantage of a definition holding for all values of the variable. Euler studied it as a definite integral in a somewhat different form from that which we shall choose.

We know that

$$\theta^{-x} \equiv 1 + x\log\frac{1}{\theta} + \frac{x^2}{2!}\left(\log\frac{1}{\theta}\right)^2 + \ldots + \frac{x^i}{i!}\left(\log\frac{1}{\theta}\right)^i + \ldots$$

for all positive values of θ and for all values of x.

$$\therefore \quad \int_0^1 \theta^{-x}d\theta \equiv \Sigma\frac{x^i}{i!}\int_0^1\left(\log\frac{1}{\theta}\right)^i d\theta,$$

but $\displaystyle\int_0^1 \theta^{-x}d\theta = \frac{1}{1-x}$ (for all values of x less than 1) $\equiv \Sigma x^i$.

Hence $$\int_0^1\left(\log\frac{1}{\theta}\right)^i d\theta \equiv i!$$

Now consider the more general integral $I_x = \int_0^1 \left(\log \frac{1}{\theta}\right)^x d\theta$ where x is not a positive integer. We shall prove (1) that it is finite if $x > -1$, but infinite (i.e. meaningless) when $x \leqq -1$; and that when $x > -1$, (2) its logarithm is a 'simple' function, and (3) it obeys the factorial law.

Since Gauss' function has been proved to be the unique 'simple' function satisfying the law and agreeing with $i!$, it will follow that the integral $(I_x) = \Pi(x)$ whenever $x > -1$.

(1) We know that $\log y \begin{matrix} < n(y^{1/n} - 1) \\ > n(1 - y^{-1/n}) \end{matrix}$ when n is positive.

$$\therefore \; I_x < \int_0^1 d\theta \left| \begin{matrix} n^x(\theta^{-1/n} - 1)^x \\ n^x(1 - \theta^{1/n})^x \end{matrix} \right| \; \therefore < \int_0^1 d\theta \left| \begin{matrix} n^x\theta^{-x/n} \\ 0 \end{matrix} \right| \text{ if } x \text{ is positive,}$$

therefore if x is positive, $I_x < \dfrac{n^x}{1 - x/n}$, n being chosen greater than x. Therefore I_x is finite when x is positive.

Now, integrating by parts,

$$I_x = \left[\theta\left(\log\frac{1}{\theta}\right)^x\right]_0^1 + \int_0^1 d\theta \,.\, x\left(\log\frac{1}{\theta}\right)^{x-1}.$$

Now if $x > 0$, $\theta\left(\log\frac{1}{\theta}\right)^x = 0$ at both limits; but if $x < 0$, $\theta\left(\log\frac{1}{\theta}\right)^x \longrightarrow +\infty$ when $\theta \longrightarrow 1$.

And when $x > 0$ $\int_0^1 \left(\log\frac{1}{\theta}\right)^x d\theta$ has been proved finite,

$\therefore \; I_{x-1}$ is also finite, $\therefore \; I_x$ is finite if $x > -1$.

Again, if $x < \left| \begin{matrix} 0 \\ -1 \end{matrix} \right|$, I_x is finite, but $I_x - xI_{x-1} \longrightarrow \infty$.

$\therefore \; I_{x-1} \longrightarrow (+\infty)$, i.e. I_x is $+\infty$ if $x < \left| \begin{matrix} -1 \\ -2 \end{matrix} \right|$

and as x increases negatively $(\log 1)^x$ becomes ∞ of a higher order, therefore I_x is meaningless if $x < -1$, but finite if $x > -1$.

We have also proved that when $x > -1$, I_x obeys the factorial law.

We now prove that $\log I_x$ is a 'simple' function.

$$\frac{d^2}{dx^2}(\log fx) = \frac{f''x}{fx} - \left(\frac{f'x}{fx}\right)^2,$$

and in this case $$f \equiv Av\left(\log\frac{1}{\theta}\right)^x,$$

$$f' \equiv Av\left\{\left(\log\frac{1}{\theta}\right)^x . \log\log\frac{1}{\theta}\right\},\quad f'' \equiv Av\left\{\left(\log\frac{1}{\theta}\right)^x . \left(\log\log\frac{1}{\theta}\right)^2\right\}$$

thus, writing l for $\log(1/\theta)$, we see that

$$f''x . fx - (f'x)^2 = (Avl^x)Av\{l^x(\log l)^2\} - \{Avl^x \log l\}^2,$$

which varies as $\Sigma l_1^x l_2^x\{(\log l_1)^2 + (\log l_2)^2 - 2\log l_1 . \log l_2\}$ (where the suffixes indicate any two values of l).

Since this expression is necessarily positive, $d^2/dx^2 (\log I_x)$ is positive, therefore $\log I_x$ is 'simple'; and, since Πx is unique by Proposition II, $I_x = \Pi x$ when it has a meaning

$$\left[\theta = e^{-z} \text{ reduces } I_x \text{ to} \int_0^\infty e^{-z}z^x dz\right]$$

PROPOSITION VII.

To prove that $\int_0^1 \theta^x(1-\theta)^y d\theta \equiv \frac{\Pi x\, \Pi y}{\Pi(x+y+1)}$ *when* $(x+1)$ *and* $(y+1)$ *are positive, and for other values of* x *and* y *is infinite.*

This integral is known as Euler's First, or Beta, Integral: though it is usual in both the Gamma and Beta integrals to write $(x-1)$ and $(y-1)$ for our x, y.

Calling the integral (x, y), we notice that $(x, y) = (y, x)$. Integrating (x, y) by parts,

$$\int_0^1 \theta^x(1-\theta)^{y+1}d\theta = \frac{1}{x+1}\left[\theta^{x+1}(1+\theta)^{y+1}\right] + \frac{y+1}{x+1}\int_0^1 \theta^{x+1}(1-\theta)^y d\theta \quad . \quad \text{(i)}$$

If $y+1>0$ and $x+1>0$, the middle term vanishes; and we have

$$(x, y+1) = \frac{y+1}{x+1}(x+1, y)$$

But writing $$(1+\theta)^{y+1} = (1-\theta)^y(1-\theta),$$

we get $$(x, y+1) = (x, y) - (x+1, y).$$

Hence
$$(x, y) = \frac{x+y+2}{x+1}(x+1, y).$$

Similarly
$$(x+1, y) = \frac{x+y+3}{y+1}(x+1, y+1).$$

therefore if $(x+1)$, $(y+1)$ are positive,

$$(x, y) = \frac{(x+y+2)(x+y+3)}{(x+1)(y+1)}(x+1, y+1) \quad . \quad \text{(ii)}$$

Now in $\int_0^1 \theta^{x+1}(1-\theta)^{y+1}d\theta$ all the elements are positive and less than unity, therefore the integral is finite.

From (ii) it follows that (x, y) is also finite, and we have

$$(x, y) = \frac{x+y+2}{x+1}(x+1, y)$$

$$\therefore \ (x, y) \cdot \frac{\Pi(x+y+1)}{\Pi x} = \frac{\Pi(x+y+2)}{\{\Pi(x+1)\}}(x+1, y) = \ldots$$
$$= \frac{\Pi(x+y+N+1)}{\Pi(x+N)}(x+N, y)$$

and
$$(x+N, y) = \int_0^1 \theta^{x+N}(1-\theta)^y d\theta = \int_0^1 (1-\theta)^y \frac{d\theta^{x+N+1}}{x+N+1}$$
$$= \int_0^1 (1-t^{1/x+N+1})^y \cdot \frac{dt}{x+N+1}$$

which
$$\rightarrow \int_0^1 \frac{\left(\log\frac{1}{t}\right)^y dt}{(x+N+1)^{y+1}} = \frac{\Pi y}{(x+N+1)^{y+1}}$$

$$\therefore \ (x, y) \cdot \frac{\Pi(x+y+1)}{\Pi x} \rightarrow \frac{\Pi(x+y+N+1)}{(x+N+1)^{y+1}} \cdot \frac{\Pi y}{\Pi(x+N)}$$
$$\rightarrow \frac{(x+N)^{y+1}\Pi y}{(x+N+1)^{y+1}} \rightarrow \Pi y$$

$$\therefore \ (x, y) = \frac{\Pi x \, \Pi y}{\Pi(x+y+1)}, \text{ if } (x+1) \text{ and } (y+1) \text{ are positive.}$$

But if $(y+1)$ is a negative fraction, and x has any value, (i) shows that

$$(x, y+1) - \frac{y+1}{x+1}(x+1, y) = \infty \ ;$$

and if $(x+1)$ is positive, $(x, y+1)$ is finite.

$$\therefore \ (x+1, y) \text{ is } +\infty.$$

Moreover any decrease in x or y increases both θ^x and $(1-\theta)^y$; therefore, when either $(x+1)$ or $(y+1)$ is negative, (x, y) is infinite and therefore meaningless.

$$\therefore \int_0^1 \theta^x(1-\theta)^y d\theta, \text{ whenever it has a meaning, } = \frac{\Pi x \, \Pi y}{\Pi(x+y+1)}.$$

Second proof that $B(x, y) = \dfrac{\Pi x \, \Pi y}{\Pi(x+y+1)}$.

This all-important Proposition can also be proved as follows:

Since $\Pi x \equiv \int_0^1 \left(\log \frac{1}{\theta}\right)^x d\theta$, if $x+1>0$, change θ to θ^V where $V>0$.

Then
$$\Pi x = \int_0^1 \left(\log \frac{1}{\theta}\right)^x \theta^V V^{x+1} \frac{d\theta}{\theta}.$$

Therefore, $f(V)$ being an arbitrary function of V,

$$\Pi x \, \Sigma f(V) = \int_0^1 \left(\log \frac{1}{\theta}\right)^x \frac{d\theta}{\theta} \, \Sigma \left\{ f(V) \, . \, \theta^V V^{x+1} \right\}$$

Let V be $\log \frac{1}{\phi}$, $f(V) \equiv \left(\log \frac{1}{\phi}\right)^y$, and $\Sigma f V \equiv \int_0^1 \left(\log \frac{1}{\phi}\right)^y d\phi \equiv \Pi y$.

If $y+1>0$, write l for $\log \frac{1}{\theta}$.

Then
$$\Pi x \, \Pi y = \int_{\theta=0}^{\theta=1} l^x(-dl) \int_0^1 d\phi \left(\log \frac{1}{\phi}\right)^{x+y+1} \theta^{\log 1/\phi}$$

and
$$\theta^{\log 1/\phi} \equiv e^{-\log 1/\theta \, . \, \log 1/\phi} = \left(\frac{1}{\phi}\right)^{-l} = \phi^l.$$

Therefore
$$\Pi x \, \Pi y = \int_{\theta=0}^{\theta=1} l^x(-dl) \, . \int_0^1 d\phi \left(\log \frac{1}{\phi}\right)^{x+y+1} \phi^l;$$

in this equation, write

$$\phi^{l+1} \equiv u, \quad \log \frac{1}{\phi} = \frac{1}{l+1} \log \frac{1}{u}.$$

Then $$\Pi x\, \Pi y = \int_0^\infty dl\,.\, l^x \int_0^1 du \left(\log \frac{1}{u}\right)^{x+y+1} \frac{1}{(l+1)^{x+y+2}}$$

$$= \Pi(x+y+1)\,.\int_0^\infty \frac{dl\,.\,l^x}{(l+1)^{x+y+2}}$$

$$\therefore \quad \frac{\Pi x\, \Pi y}{\Pi(x+y+1)} = \int_0^1 d\left(\frac{l}{l+1}\right)\cdot\left(\frac{l}{l+1}\right)^x\left(\frac{1}{l+1}\right)^y = \int_0^1 d\theta\,.\,\theta^x(1-\theta)^y.$$

PROPOSITION VIII.

Expansion of log Πx and Πx.

From Gauss' definition :

$$\log \Pi x = Lt\left[x \log N + \log \Pi N - \sum_{i=1}^{N} \log(x+i)\right]$$

$$\therefore \quad \frac{\Pi' x}{\Pi x} = Lt\left[\log N - \sum_1^N \frac{1}{x+i}\right]$$

$$\therefore \quad \Pi' 0 = Lt\left[\log N - \sum_1^N \frac{1}{i}\right] = Lt\left[\log\left\{\frac{N}{N-1}\cdot\frac{N-1}{N-2}\cdots\frac{2}{1}\right\} - \sum_1^N \frac{1}{i}\right]$$

$$= Lt \sum_1^N \left[\log\frac{i+1}{i} - \frac{1}{i}\right] \text{which} < Lt \sum_1^N \left[\left|\begin{matrix}\frac{1}{i}\\ \frac{1}{i+1}\end{matrix}\right| - \frac{1}{i}\right]$$

$$\therefore \quad \Pi' 0 < \left|\begin{matrix}0\\ \frac{1}{N+1} - 1\end{matrix}\right| \text{ and is therefore a definite quantity.}$$

It is known as 'Euler's Constant' (γ), and $\gamma = -\cdot5772156649\ldots$

$$\frac{d^2}{dx^2}\log \Pi x \equiv +\sum_1^\infty \frac{1}{(x+i)^2} \text{ which } < \left|\begin{matrix}\frac{1}{x}\\ \frac{1}{x+1}\end{matrix}\right|$$

$$\frac{d^n}{dx^n}\log \Pi x \equiv (-)^n (n-1)!\sum_1^\infty \frac{1}{(x+i)^n} \text{ which } < (-)^n (n-2)!\left|\begin{matrix}\frac{1}{x^{n-1}}\\ \frac{1}{(x+1)^{n-1}}\end{matrix}\right|$$

therefore, putting $x = 0$ we get the convergent expansion (when $x < {}^{1}_{-1}$)

$$\log \Pi x = \gamma x + \frac{x^2}{2} S_2 - \frac{x^3}{3} S_3 \ldots (-)^n \frac{x^n}{n} S_n \ldots$$

where
$$S_n \equiv \sum_1^\infty \frac{1}{i^n}$$

To expand Πx,

$$\frac{d^2}{dx^2} \log \Pi x \equiv \frac{\Pi'' x}{\Pi x} - \left(\frac{\Pi' x}{\Pi x}\right)^2 \therefore \Pi'' 0 = (\Pi' 0)^2 + S_2 = \gamma^2 + S_2$$

so
$$\frac{\Pi''' x}{\Pi x} - 3\frac{\Pi' x\, \Pi'' x}{(\Pi x)^2} + 2\left(\frac{\Pi' x}{\Pi x}\right)^3 = (-)^3\, 2\,!\, S_3$$

$$\therefore \quad \Pi''' 0 = 3\gamma(\gamma^2 + S_2) - 2\gamma^3 = \gamma^3 + 3\gamma\, S_2 + 2S_3 - 2S_3$$

and so on. We add a proof that if Πx is expanded in positive powers of x, the ultimate remainder is comparable with $(-x)^N$ and therefore the expansion is possible if, and only if, $x < {}^{1}_{-1}$. The proof has some points of interest, but of course the case is covered by the theory of radius of convergence.

PROPOSITION IX.

Proof that Πx can be expanded in powers of x, if $x < {}^{1}_{-1}$.

We have $\Pi x \equiv \int_0^1 \left(\log \frac{1}{\theta}\right)^x d\theta$, if $x > -1$,

$$\therefore \quad \Pi^n(x) \equiv \int_0^1 \left(\log \frac{1}{\theta}\right)^x \left(\log \log \frac{1}{\theta}\right)^n d\theta,$$

$$\equiv \int_0^\infty l^x (\log l)^n \,.\, e^{-l} dl.$$

Divide the integral into two parts $l = 0$ to $l = 1$ and $l = 1$ to $l = \infty$.

The first part may be written $(-)^n \int_0^1 l^x e^{-l} \left(\log \frac{1}{l}\right)^n dl.$

Let $l \equiv \lambda^a$, where a is some positive quantity.

We get
$$(-)^n a^{n+1} \int_0^1 d\lambda \,.\, l^{x+1-1/a} e^{-l} \left(\log \frac{1}{\lambda}\right)^n d\lambda.$$

Now $(l^{x+1-1/a}e^{-l})$ increases or diminishes, as l increases, according as $\left(x+1-\frac{1}{a}\right)\frac{1}{l} \gtrless 1$, $\therefore\ L = x+1-\frac{1}{a}$ gives a maximum value, therefore the integral is numerically less than $(-)^n a^{n+1} e^{-L} L^L \,.\, \Pi n$.

Also it will be found that $a^{n+1}e^{-L}L^L$ increases as a increases: therefore $a = 1/(x+1)$ gives the minimum value.

Hence this first part of the integral lies between

$$(-)^n (x+1)^{-n-1} \,.\, \Pi n \left| \begin{matrix} 1 \\ e^{-1} \end{matrix} \right|$$

For the second part $\int_1^\infty dl \,.\, l^x e^{-l} (\log l)^n$, let $l \equiv \lambda^{-\beta}$ where β is positive.

We get $\beta^{n+1} \,.\, \int_0^1 d\lambda \left(\log \frac{1}{\lambda}\right)^n \,.\, \left| l^{x+1+1/\beta} e^{-l} \right|$; and, as before, $l^{x+1+1/\beta}e^{-l}$ has a maximum when $l = x+1+1/\beta \equiv L$.

Moreover $\beta^{n+1}L^L e^{-L}$, as β increases, has a rate of increase varying with $(n+1/\beta - 1/\beta^2 \log L)$, which is positive if n is big enough; and, choosing β to be small, $\beta^{n+1}L^L e^{-L}$ is small: therefore the second part of the integral bears a negligibly small ratio to Πn, when n is big.

Now, the remainder after x^{N-1} in the expansion of $\Pi(a+x)$ is $\int_0^x \Pi^N(a+x-z) \,.\, \frac{dz^N}{N\,!}$, which by the above results

$$< \left| \begin{matrix} 1 \\ e^{-1} \end{matrix} \right| (-)^N \int_0^x (a+x-z+1)^{-N-1} dz^N$$

$$< \left| \begin{matrix} 1 \\ e^{-1} \end{matrix} \right| (-)^N \int_0^x \left(\frac{a+x-z+1}{z}\right)^{-N-1} . N \frac{dz}{z^2}$$

$$< \left| \begin{matrix} 1 \\ e^{-1} \end{matrix} \right| \frac{(-)^N}{a+x+1} \int_0^x u^{N+1} N \frac{du}{u^2} \quad \text{where } \frac{1}{u} \equiv \frac{a+x+1}{z} - 1$$

therefore remainder $< \left| \begin{matrix} 1 \\ e^{-1} \end{matrix} \right| \frac{(-x)^N}{a+x+1}$

This gives the required result for the expansion of Πx, when $a = 0$, with the additional result that, when $a+1 > 0$, $\Pi(a+x)$ can be explained in powers of x when, and only when, $|x| < 1$.

In all cases the range of $(a+x)$ must not include $-1, -2, \ldots$, where discontinuity occurs.

PROPOSITION X.

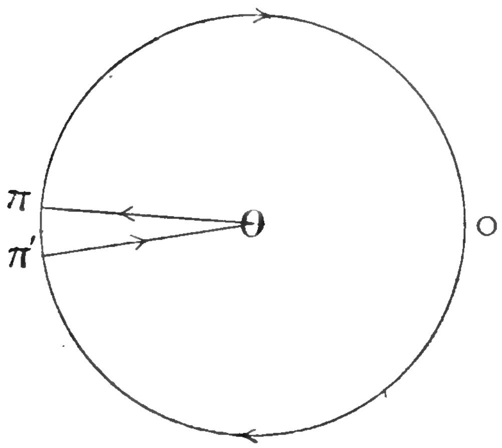
The extended Binomial Coefficient $(n)_a \equiv \dfrac{\Pi n}{\Pi(n-a)\Pi a}$ *is the contour integral* $\dfrac{1}{2\pi\iota}\displaystyle\int(1+z)^n z^{-a-1}dz$ *round the unit circle, when* $n > -1$ *and* a *has any value.*

Consider $\displaystyle\int z^a(1+z)^\beta \frac{dz}{z}$ over the closed path $O\pi o\pi' O$ (unit circle). The whole integral being zero, the integral over the circle $\pi' o\pi$

$$= \int_0^1 \frac{dx}{x}\left\{(xe^{\iota\pi})^a(1-x)^\beta - (xe^{-\iota\pi})^a(1-x)^\beta\right\}$$

which $$= 2\iota\sin a\pi\int_0^1 x^{a-1}(1-x)^\beta dx = 2\iota\sin a\pi\,.\,\frac{\Pi(a-1)\Pi\beta}{\Pi(a+\beta)}$$

if $$a > 0 \text{ and } \beta > -1,$$



and, by Proposition IV, $\quad \Pi(-a)\,.\,\Pi a = a\pi/\sin a\pi,$

$$\therefore \int_0^1 dz\,.\,z^{a-1}(1+z)^\beta = 2\pi\iota\,.\,\frac{\Pi\beta}{\Pi(\beta+a)\Pi(-a)} = 2\pi\iota\,.\,(\beta)_{-a},$$

therefore when $\beta > -1$ and $a > 0$, $(\beta)_{-a} = \dfrac{1}{2\pi\iota}\displaystyle\int dz\,.\,z^{a-1}(1+z)^\beta$ round the unit circle; call the right side $Av\, z^{a-1}(1+z)^\beta$;1 or $(a-1,\ \beta)$. We proceed to prove that the restriction $a > 0$ may be removed.

$$(a-1,\ \beta+1) = Av\, z^{a-1}(1+z)^{\beta+1} = Av\, z^{a-1}(1+z)\,.\,(1+z)^{\beta}$$

$$= (a-1,\ \beta)+(a,\ \beta) \text{ for } \textit{all} \text{ values of } a,\ \beta \quad . \quad \text{(i)}$$

and, integrating by parts,

$$Av\, z^{a-1}(1+z)^{\beta+1} = \frac{1}{a}\,[z^{a}(1+z)^{\beta+1}] - \frac{\beta+1}{a}\, Av\, z^{a}(1+z)^{\beta}.$$

Now, if $\beta > -1$, and a is arbitrary, the limit terms vanish, and

$$(a-1,\ \beta+1) = \frac{\beta+1}{-a}\,.\,(a,\ \beta).$$

Hence, by (i), $(a-1,\ \beta) = \dfrac{\beta+a+1}{-a}\,(a,\ \beta)$, whatever a may be, if $\beta > -1$.

Now, if $a > -1$, $(a,\ \beta) = (\beta)_{-a-1}$,

$$\therefore\ (a-1,\ \beta) = \frac{\beta+a+1}{-a}\,.\,\frac{\Pi\beta}{\Pi(\beta+a+1)\Pi(-a-1)} = (\beta)_{-a}$$

Hence it follows (if $\beta > -1$) that $(a-2,\ \beta) = (\beta)_{-a+1}$, and so universally.

The following Propositions follow from those proved in this paper, and are of some interest:—

A. $\sum\limits_{i=0} (m)_{a-i}(n)_i = (m+n)_a$ for all values of a, if $m+n+1>0$.

B. $(1+u)^n = \sum\limits_{-\infty}^{\infty} (n)_{a+1} u^{a+1}$, when u is any unit vector, if $n>0$.

Defining *fractional differentiation* by $D^n x^m \equiv \dfrac{\Pi m}{\Pi(m-n)}\, x^{m-n}$,

C. $D^n(uv) = \sum (n)_i\,.\,D^{n-i}u\,.\,D^i v$, but $D^n_x f(a+x)$ is *not* $f^n(a+x)$.

D. **Legendre's Coefficient in Spherical Harmonics**

$$P_n = \frac{1}{\Pi n} D_t^n \, (t^n t'^n)$$

where $t = \sin^2\theta/2$, $t' = \cos^2\theta/2$, and n has *any* value. Also, if $\cos\theta$ is positive,

$$P_n = \frac{1}{2\pi}\int_0^{2\pi} d\phi \, . \, (\cos\theta + \iota \sin\theta \cos\phi)^{-n-1}$$

E. **Laplace's Coefficient is**

$$(\text{constant}) \; D_t^{n \pm m} \mid t^n t'^n \mid$$

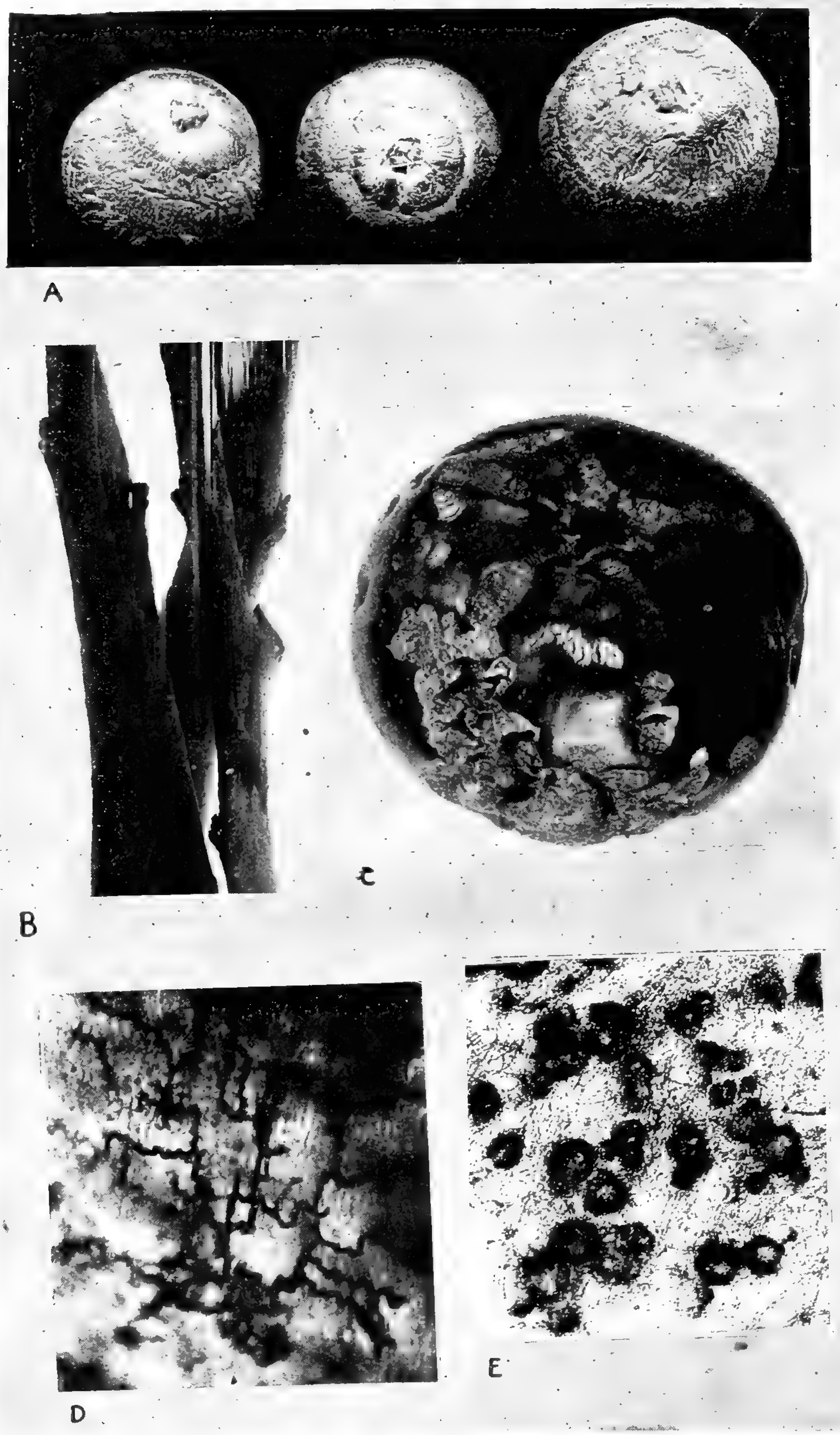
F. **The Hypergeometric Series can be written**

$$D^a \{x^b(1-x)^c\} \text{ or } \sum_0 (m)_{a-i}(n)_2 \, . \, x^i.$$

Physical Chemistry.—Prof. H. E. Armstrong, in a thoroughly characteristic speech in Melbourne, about two years ago, said that physicists have unfortunately in the past held aloof from chemists, and therefore the movement now in progress is to be welcomed, for its effect must be to lead the two parties to work together to a common end. Parenthetically, however, he observed that the views now advocated by physicists are entirely different from any conceptions that chemists have ever entertained, and hence are not easily assimilable. A day or two previously Prof. W. J. Pope had also referred to the sharp divergence between the chemistry and the physics of twenty years ago, and had remarked on the interesting fact that the two sciences were now again converging, for many purely chemical questions had received such full quantitative study that the results are susceptible to attack by the methods of the mathematical physicist; while the intense complication of many physical problems—problems whose intricacies the traditional mathematical mode of attack of the physicist had proved powerless to deal with—had led to their interpretation by the logical argument of the chemist. A third of a century ago the present-day conception of physical chemistry had no existence: since then a flood of light has suffused the very inward parts of chemical structure, and stereochemistry has taken a most definite place amongst the branches of chemical science. Physical chemistry, widely extensive and deeply intensive as it is, has practically moulded itself into the shape of a new science out of the coter-

minous territories of the once divergent chemistry and physics, and the mere fact that so eminent a chemist as the late Sir William Ramsay undertook the editorship thereof is sufficient proof that the highly important series of text-books on Physical Chemistry, which is in course of preparation, has been written without any of the "mutual misunderstandings" to which Dr. Pope referred in his Australian address. The series now consists of some sixteen volumes, dealing with such subjects as stoichiometry, chemical statics and dynamics, the phase rule and its applications, thermochemistry, stereochemistry, electrochemistry, the theory of valency, spectographic analysis, and the relation between chemical constitution and physical properties. One of the most valuable works of the series has recently appeared,* and is intended to be used as a general text-book of physical chemistry by those who have already acquired some knowledge of both physics and chemistry. Prof. Lewis explains, in the preface to his two volumes, that his "system" consists in regarding all physico-chemical phenomena as being capable of separation into two classes: (1) phenomena exhibited by material systems when *in* a state of equilibrium, and (2) phenomena exhibited by material systems which have *not* reached a state of equilibrium. Volume 1 deals with the phenomena of chemical equilibrium from the kinetic point of view, while Volume 2 deals with considerations based upon thermodynamics and from the standpoint of the new statistical mechanics. The student of twentieth-century chemistry will find much to interest him: he will find described recent work on the structure of the atom and the magnitude of molecules, the transmutation of the elements, and the distribution of molecules in space; he will also find much on the subject of the theory of concentrated solutions and of capillary chemistry. The second volume commences with a great deal of fairly stiff mathematical analysis, but it closes with a section in which radiation and photo-chemistry are first discussed, and experimental evidence is adduced in favour of the discrete nature of radiant energy. Both volumes are fully indexed and well provided with bibliographies, and, as already indicated, a special feature of the entire work is the thoroughly up-to-date manner in which the latest developments of physico-chemical science are set forth.

* Lewis, W. C. McC.: "*A system of physical chemistry,*" Vols. 1 and 2. pp. xiv, 523; vii, 552. London: Longmans, Green & Co., 1916. 9s. net per volume (sold separately).



P. A. van der Byl.—The Genus Coniothecium.

NOTE ON THE GENUS *CONIOTHECIUM*, CORDA.: WITH SPECIAL REFERENCE TO *CONIOTHECIUM CHOMATOSPORUM* CORDA.

By Paul A. van der Bijl, M.A., D.Sc., F.L.S.

(*Plates 29-34 and two text figures.*)

Introduction.

Elsewhere* I have described an apple blister and apple cracking disease as due to *Coniothecium chomatosporum* Corda, and later Massee,† in his paper "Blister Disease of Fruit Trees," wrote:—

> What appears to be the same disease has been described by Pole Evans and P. A. van der Bijl‡ as present on apple trees in South Africa In this instance, however, the authors were only acquainted with one stage in the life-cycle of the fungus concerned, to which they applied the name *Coniothecium chomatosporum* Corda.

True, in the articles referred to there is no mention of any other stage in the life-cycle, yet the latter author had at that time come across *Phoma* pycnidia in *Coniothecium* cultures, and his only reason for not mentioning it was that he intended to complete the investigation which, owing to pressure of work of more direct agricultural importance, had to be discontinued at the time the above article appeared.

In view of Massee's paper, and as it may be some time before the opportunity arises for continuing this investigation, the author thinks it best to publish the results he has arrived at. It may be mentioned here that these results were obtained before the publication above-mentioned went to the press.

The genus *Coniothecium* was founded by Corda §, who distinguishes it under the following characters: "Sporæ simplices, in globulos corneos irregulariter conglutinatæ et acervulos effusos vel solitarios, rarius stromate suffultos referentes. Color obscurus."

From the above it is evident that the genus *Coniothecium* is very badly defined, and various authors have from time to time brought forward evidence which appears to indicate that *Coniothecium* is nothing else but a stage in the life-history of one or more of the higher fungi.

Before proceeding to detail the results arrived at, it may be well to call attention to some of the older works.

Marshall Ward‖ (1900) has obtained in pure culture a *Coniothecium* from *Dematium pullulans* de By. et Löw.

* Van der Bijl, P. A.: "Apple-cracking and apple branch blister, etc." *Agr. Journ. Union of South Africa*, **8** [1], 64.

† Massee, G.: "Blister disease of Fruit Trees," Kew Bull., No. 3, (1915), 104.

‡ Pole Evans, I. B.: "Notes on Plant Diseases." *Trans. Agr. Journ.*, **5**, 680.

§ Corda, A. C.: "Icones Fungorum," I., p. 2.

‖ Ward, H. Marshall: "The Nutrition of Fungi," British Mycological Soc. Trans. for Session 1899-1900, p. 134.

Neger * (1896) holds that *Coniothecium* forms part of the life cycle of *Antennaria scoriadea* Berk.

Guéguen † (1902) has published an excellent account on the morphology, physiology, and systematic position of the group. He studied especially *C. Amentacearum* Corda, and notes the following chief points:—

(1) The spores germinate readily in Raulin's gelatin within five hours. They do not increase sensibly in size, but round themselves and become lighter in colour. From one or two points, rarely more, a refringent cylindrical or slightly attenuated germ tube is given off which becomes septate.

(2) The formation of typical *Coniothecium* spores.

(3) Certain mycelial branches enrol themselves without leaving the surface of the substratum, forming a complicated cushion resembling a parcel of rope, or a spiral squeezed and enrolled in divers ways. These structures were of frequent occurrence in gelatin cultures, but appeared more abundantly in distilled water. He draws attention to the resemblance of this structure to the first stages in the development of the *ascophores* of certain *Pyrenomycetes*.

(4) The formation of small nodular swellings borne on a short branch, or formed at a region of anastomoses. These nodules increase in size, acquire a diameter double or treble that of the mycelium, and at the same time roll themselves into a tight spiral. Their contents become very refringent, and their membranes thicken and colour. Often they give out a kind of short bud which enrols itself on it. A mass of irregular lobes of various forms is produced which resemble a mass of *Coniothecium* spores.

(5) The formation of buds on the mycelium. These buds never fall off, and were not observed to germinate. Bodies similar to these buds, but more fusiform, were also found.

(6) The anastomoses of hyphæ, which too become torulate and resemble a *Fumago*. The formation of intercalary chlamydospores, or the dissociation of the cells of the hyphæ.

(7) The formation of broom-like or feather-like structures borne either on a mycelial coremium or arising from numerous anastomoses. They arise in a way analogous to similar structures which Matruchot ‡ found constant in *Gliocladium viride* Matr.

(8) The formation of coremations.

(9) From his study he concludes that *Coniothecium*, and in particular *Coniothecium Amentacearum* Corda, must be considered an imperfect form of a genus related to *Capnodium*.

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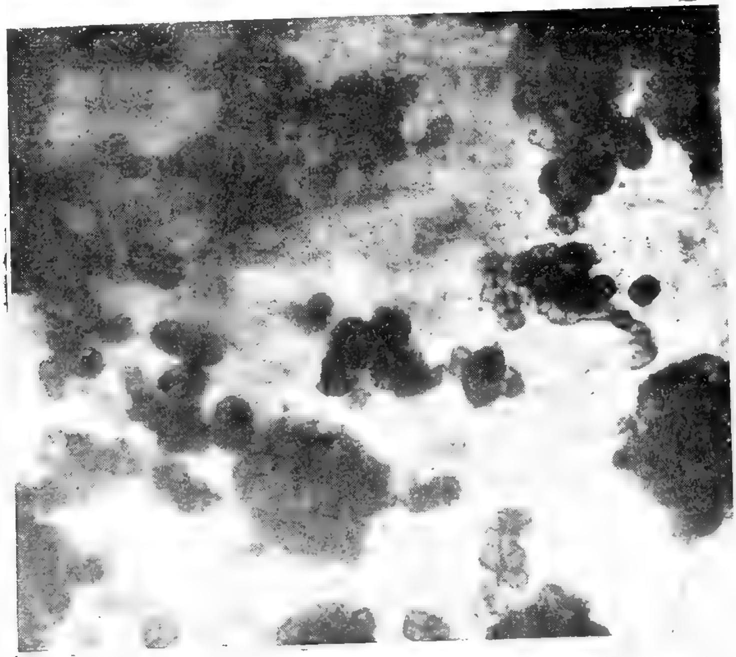
* Neger: "Ueber ein neue Fruchtform eines Fumago-ahnlichen Pilzes, Antennaria scoriadea Berk., C.f.B.Dd. II, Abt. II, S. 613

† Guéguen, F.—Reserches sur la Morphologie, le Developpement et la position Systematique des Coniotheciums. *Bull. de la Soc. Myc. de France*, **18**, 151.

‡ Matruchot, M.: "Sur un Gliocladium nouveau," *Bull. de la Soc. Myc. de France*, **9**, 249.



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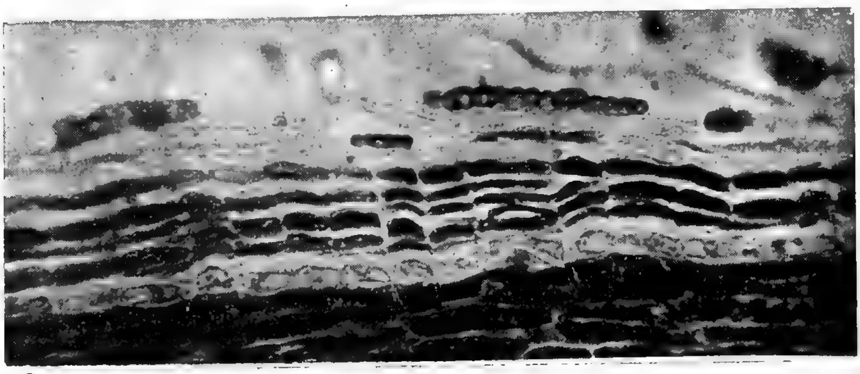

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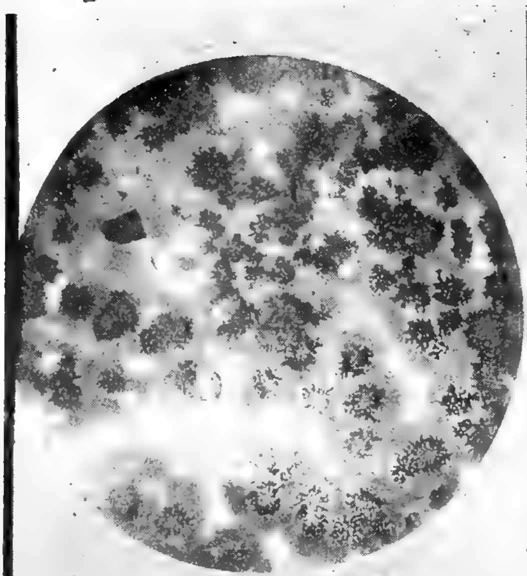

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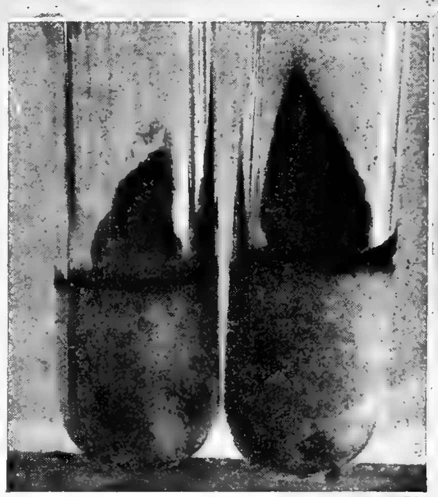

D

P. A. van der Byl.—The Genus Coniothecium.

Massee, in his paper referred to, wrote: "Hence, in future *Coniothecium* will only be retained as a form-genus until its components are correlated with their respective *Phoma* forms." His evidence is briefly this: (1) The appearance of the *Phoma* stage when budding *Coniothecium* spores are sown in petri-dish cultures; (2) *Phoma* spores from these cultures gave origin first to the *Coniothecium* and afterwards to the *Phoma* condition; (3) Phoma spores from above source when placed on young apple shoots gave origin to the *Coniothecium* condition of the fungus.

In addition, he holds that the ascigerous stage of the fungus is *Diaporthe ambigua* Nits. He met with this stage only once accompanying the *Phoma* on a dead apple twig. These ascigerous spores on nutrient media gave origin to the *Phoma* without the intervention of *Coniothecium,* which, however, formed when the *Phoma* spores were sown.

The author holds that the *Phoma* and *Diaporthe* forms are pure saprophytes appearing on the branches killed by the *Coniothecium,* which is the only parasitic form included in the life-cycle of the fungus.

The relationship of the fungi known as *Coniothecium chomatosporum* Corda, *Phoma Mali* Schulz. & Sacc., and *Diaporthe ambigua* Nits., he regards as fully established, and goes further, as is seen from the paragraph quoted above.

The author* states that C. O. Farquharson, in an incompleted investigation on a water-lily disease, was the first to demonstrate that *Coniothecium* resulted from the germination of *Phoma* spores, and that subsequently he proved that the spores of *Phoma abietis* Br. produced on germination a *Coniothecium* stage.

Other writers have regarded *Coniothecium* as forming part of the cycle of fungi other than those enumerated, but as the original works were not available, the reader must refer to Guéguen† for the references.

Present Observations.

1. *Blister Disease of Fruit Trees and Cracking of Fruit.*

Blister disease (Pl. 29, *b*) is of frequent occurrence on the branches of apple and pear trees in South Africa, and a surface section shows us the olive-coloured mycelium giving rise to clusters of large globose cells (Pl. 29, *d*, and Pl. 30, *a*)—the *Coniothecium* stage of the fungus. The blackish olive colour of the blisters is due to the dark colour of the fungus.

A transverse section through a "blister" (Pl. 30, *b*) shows us the olive brown cells of the fungus between the cells of the host plant. The fungus evidently invades the middle lamellæ of the cells, as is evident from both surface and transverse sections. As a result, the cells separate, press outwards, and thus ultimately the skin over the blister is ruptured.

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* *Op. cit.*, p. 106.

† *Op. cit.*, pp. 151-155.

On the fruit the fungus produces a scurfy condition known as "russeting" (Pl. 29, *a*). If the fruit is attacked while young, the fungus causes it to crack on expanding (Plate 29, *c*). These cracks become deeper and deeper with the increase in size of the fruit, and when the core is reached the fruit soon withers and dies.

The spores usually found on diseased material are the *Coniothecium* form. The ascigerous form has to the present not come to my notice in South Africa.

The disease is best controlled by the pruning back and destruction of diseased parts, accompanied by cleansing sprays in winter.

2. *Isolation of the Fungus.*

On 26th September, 1913, pieces of apple bark, on which only the *Coniothecium* form was present, were sterilised in mercuric chloride (1 : 1000), washed in distilled water, then shaken up in melted beerwort gelatine tubes and plates, which were incubated at 20° C. poured. Seven days after inoculation the fungus was evident round the pieces of bark and elsewhere, and the following fruiting bodies were observed: (1) *Phoma pycnidia,* with spores; (2) *Coniothecium* spores; (3) *Alternaria-like* spores.

Plates subsequently poured from blisters on apple branches always gave origin to the *Phoma,* and the same resulted in plates poured from a diseased pear branch (Pl. 30, *c*).

3. *Growth on Various Media.*

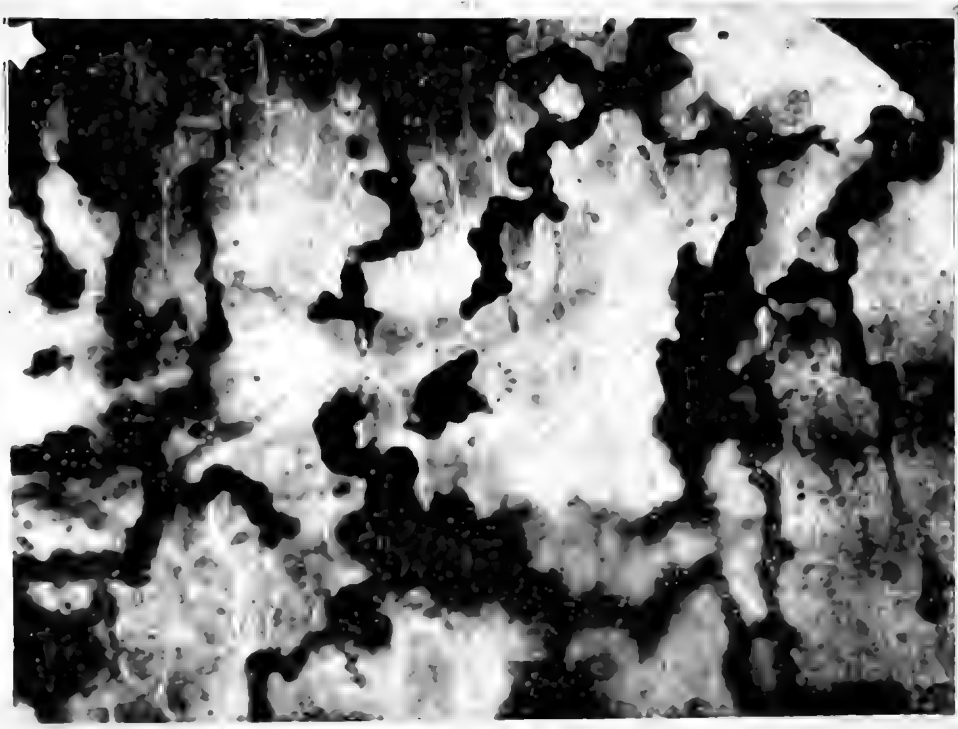
On sterilised apple plugs at 20° C. numerous *Phoma pycnidia* were produced, and after 25 days there was a mouse-grey mycelial growth (Pl. 30, *d*) and *Coniothecium* spores in it. The fungus grows on the cotton wool, and where it comes into contact with the glass, just above the cotton wool, forms a dark brown rim.

The *Phoma* also readily formed on sterilised apple twigs, where also raised pustule-like bodies, consisting of a mass of *Phoma pycnidia,* were observed. A thin slice off the back of the plug gave numerous *Coniothecium* spores (Pl. 31, *a*). On the liquid in which the plug stands the fungus forms a flap of growth, in which were numerous resting spores (*Coniothecium*), and after 25 days *Alternaria-like* spores (Pl. 31, *b*) in the mole-greyish growth. The *pycnidia* also readily formed in prune agar (Pl. 32, *a*), and on sterilised bean stalks and leaves (Pl. 32, *b* and *c*).

On Carrot agar (Pl. 32, *d*) it forms small colourless colonies of convex elevation measuring 5 mm. across. The fungus threads frequently radiate out from these colonies, which become dotted over with *Phoma* pycnidia and thus much darker in colour.

On treacle agar (Pl. 32, *e*) there formed dark filamentous colonies and numerous *Phoma* pycnidia. Here, too, were observed a few packets of *Coniothecium* spores.

It was now left to proceed from the one kind of spores, and by sowing it alone in suitable media to produce the other.



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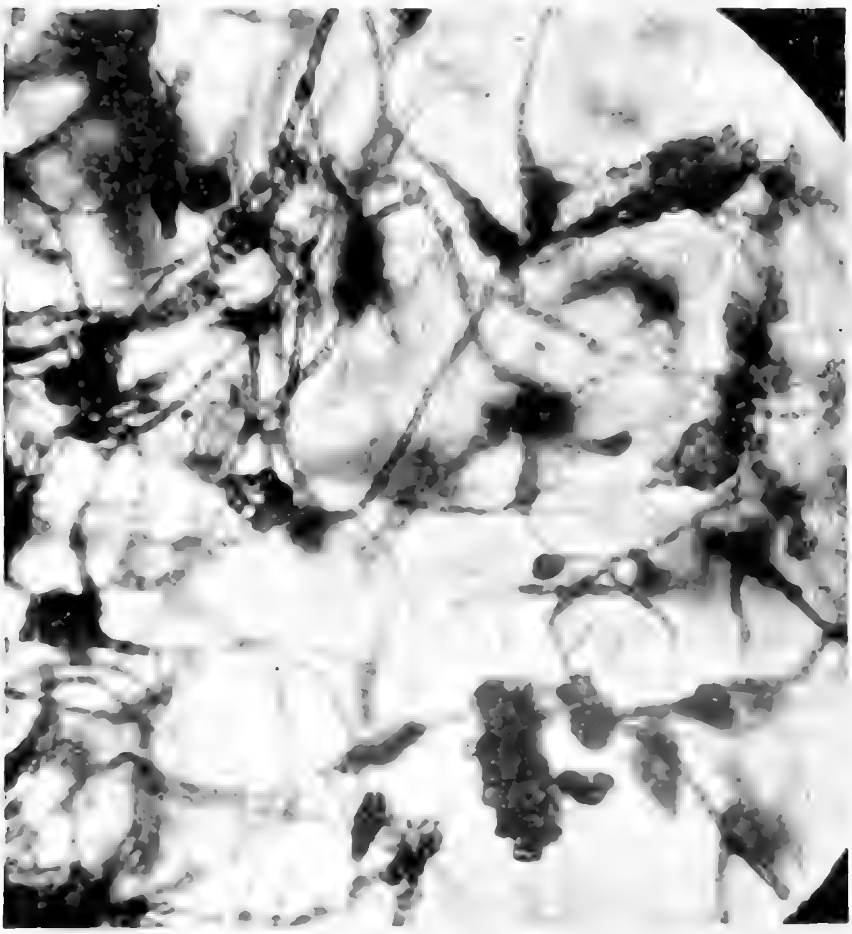

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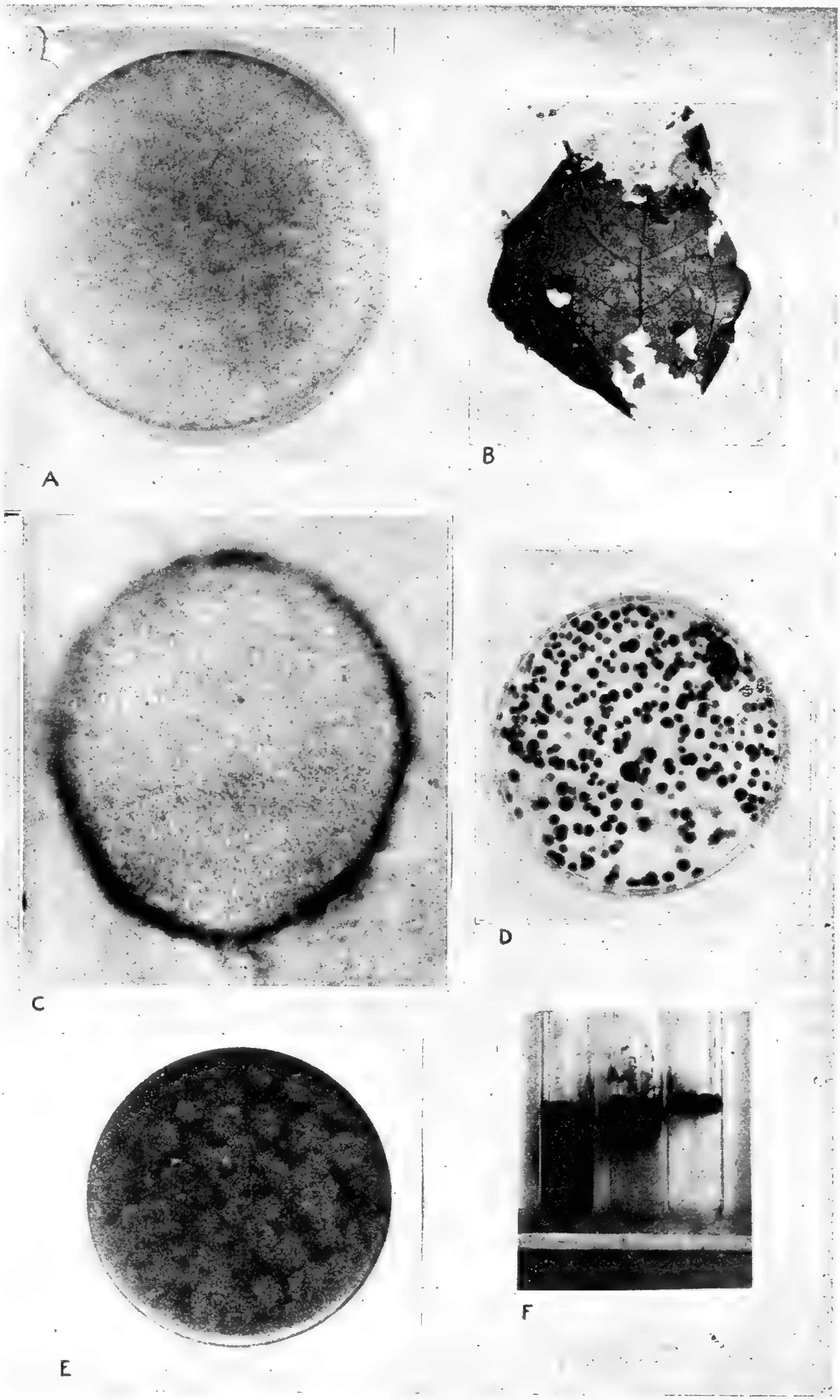
P. A. VAN DER BYL.—THE GENUS CONIOTHECIUM.



P. A. van der Byl.—The Genus Coniothecium.

On the 7th February, 1914, only *Phoma* spores were sown in the following media:—

(1) Dox solution* + .4 per cent. malic acid.
(2) Dox solution + .4 per cent. gallic acid.
(3) Dox solution + 1.5 per cent. dextrose.

Pl. 32, *f* represents the fungus growing in the above three media, and the results of examination are briefly expressed below:—

On the 16th February, 1914—

Dox + 1.5 per cent. Dextrose.—Growth on top of liquid. Numerous pycnidia. Mycelium in places rounded.

Dox + .4 per cent. Malic Acid.—Small white colonies on top of liquid and along glass. (18th February, 1914, pycnidia.)

Dox + .4 per cent. Gallic Acid.—Small white colonies on surface of liquid and at bottom of tube. Mycelium in places, brown, and rounding off.

On the 20th February, 1914—

Dox + 1.5 per cent. Dextrose.—Some of the cells, especially of hyphæ along the glass, have turned a brown, rounded off, and are very suggestive of *Coniothecium* spores.

Dox + .4 per cent. Malic Acid.—The coloured growth on the sides of the glass show *Phoma* pycnidia. The cells are a light brown, but there are as yet no typical *Coniothecium* spores.

Dox + .4 per cent Gallic Acid.—Just above liquid, along the glass, the growth had turned brown, and examination showed typical *Coniothecium* spores (Pl. 33, *a* and *b*).

On the 23rd February, 1914—

Dox + 1.5 per cent. Dextrose.—Typical *Coniothecium* spores (Pl. 33, *c* and *d*, and Pl. 34, *a*).

Dox + .4 per cent. Malic Acid.—*Coniothecium* spores (Pl. 34, *b* and *c*.)

These experiments, I believe, are conclusive that the *Coniothecium* under consideration is but a stage in the life cycle of the *Phoma* found. Often the mycelium was not quite as dark as that typical for *Coniothecium*, but this is only a minor point where the general form agrees well with the fungus in question.

Not only was the *Coniothecium* produced by sowing *Phoma* spores, but the two were found intermingled on the majority of media, and even on the host. It was this latter fact which first suggested the relation between the species of the two genera in question.

It is premature to predict that further research will result in the placing of all the *Coniotheciums* in the genus *Phoma.* The question can only be settled by the cultivation and study of these forms in the laboratory, but in such an ill-defined genus as *Coniothecium*, it is highly probable that it will ultimately be related to not one, but a number of other genera.

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* Thom, Charles: "Cultural Studies of Species of Penicillium," U.S.A. Bureau Animal Industry, Bull. 188, p. 22.

General Considerations.

On culture media the mycelium, at first colourless, later becomes dark brown and torulate. This torulate condition is also evident in the mycelium on the host.

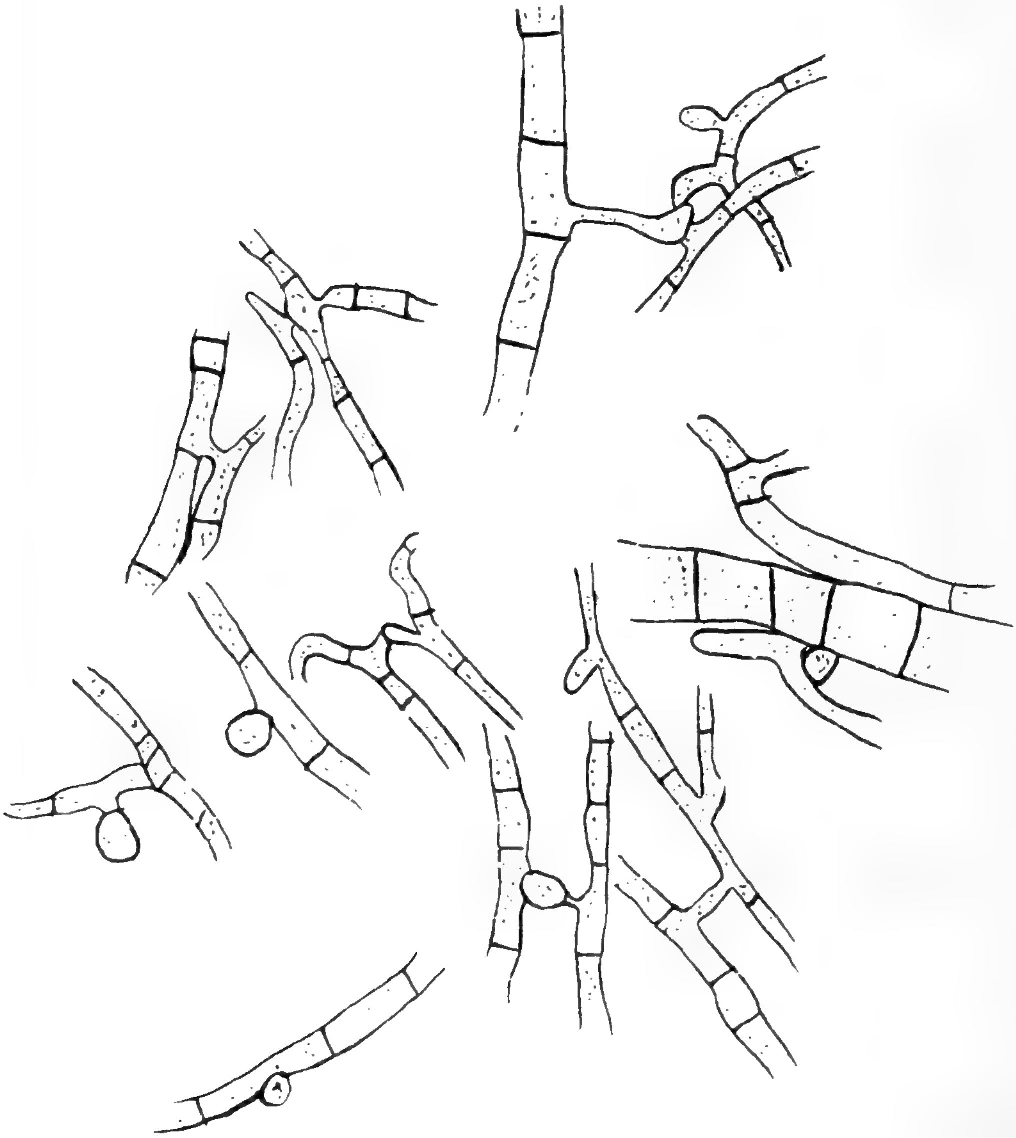
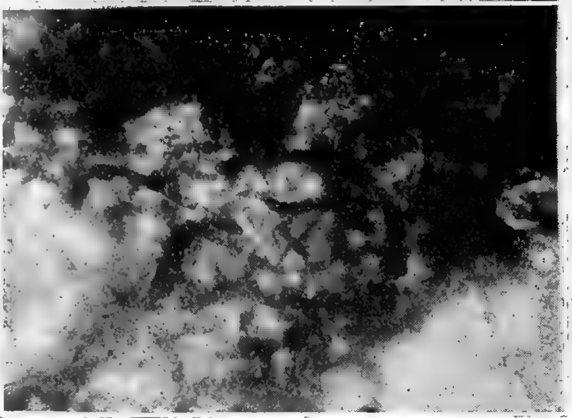


Fig. 1.

In the media this condition results ultimately in the formation of intercalary chlamydospores, and the packets of *Coniothecium* spores evidently arise by these torulate cells remaining united, dividing, and the individual cells expanding. This is borne out by certain stages in the formation of these cells as observed in cultures.

The mycelium on all the media is distinctly septate and branched. The individual cells are usually 13.2 to 26.4 μ long, though longer cells are present. The hyphæ vary greatly in breadth, the coloured being invariably broader and firmer than the colourless, and usually measure 4.95 to 6.6 μ across.



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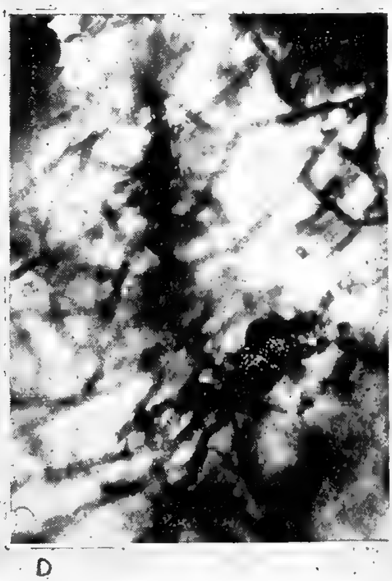

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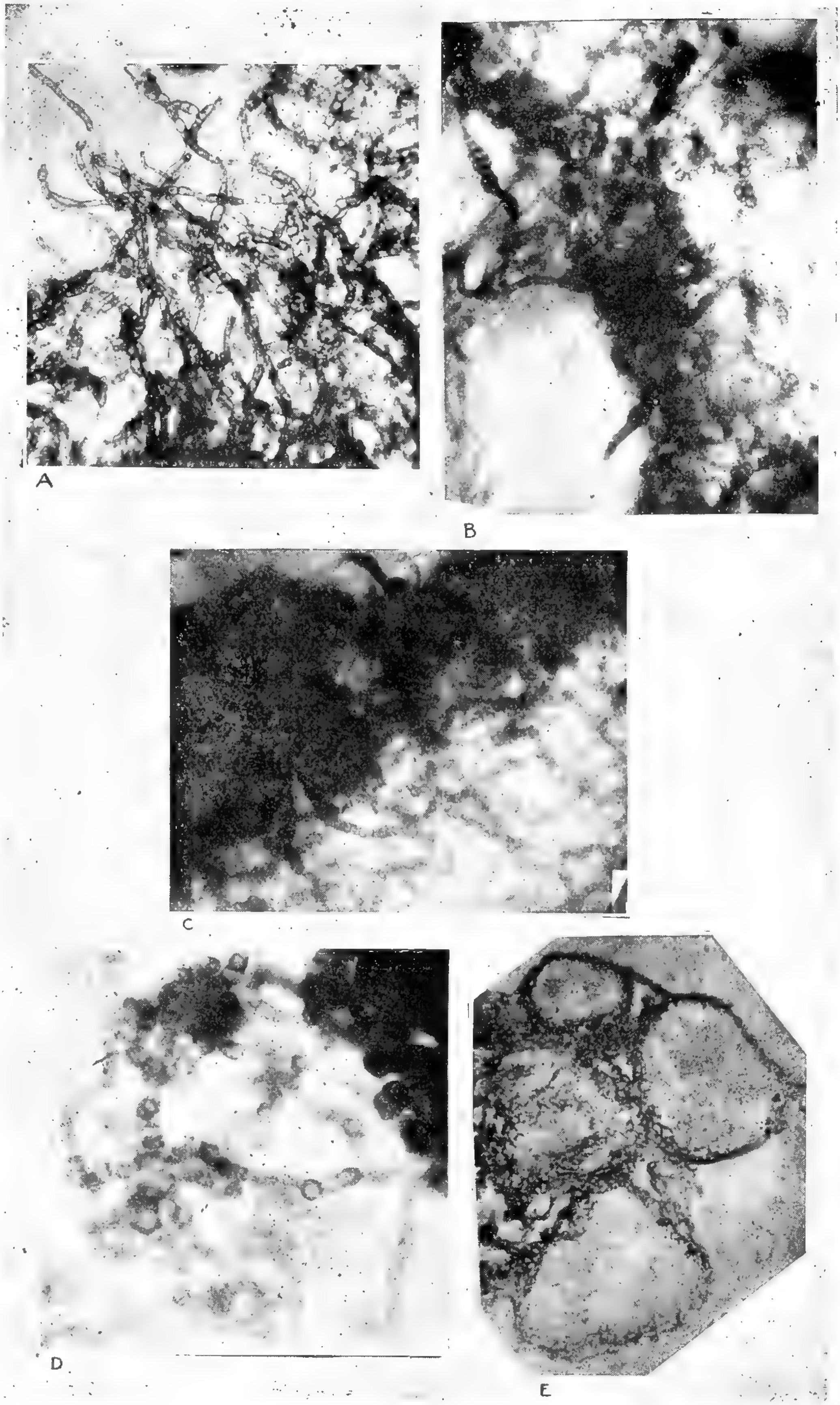
P. A. van der Byl—The Genus Coniothecium.



P. A. van der Byl.—The Genus Coniothecium.

In the greyish growth on sterilised apple-twig, large globular intercalary cells, somewhat lighter than typical *Coniothecium,* were observed, and similar cells formed on beerwort gelatine (Pl. 34, *d*). On the latter there were also packets of typical *Coniothecium* spores, and the conclusion is arrived at that they result by walls forming in the above cells.

The formation of conidial masses (*Coniothecium*) where hyphæ cross or touch have frequently been observed, and is in agreement with the observation of Guéguen on the formation of these bodies.

Clamp connections between individual cells are frequently present (Fig. 1), but in no cultures have I observed anything resembling the brush-like structures of Guéguen, though simple coremations (Pl. 33, *c*), such as represented in Guéguen's Fig. 14, are present.

Buds on the mycelium, as figured by Guéguen, frequently form, and are usually more or less rounded (Pl. 34, *d*), and never fusiform or elongated. Attempts were not made to germinate

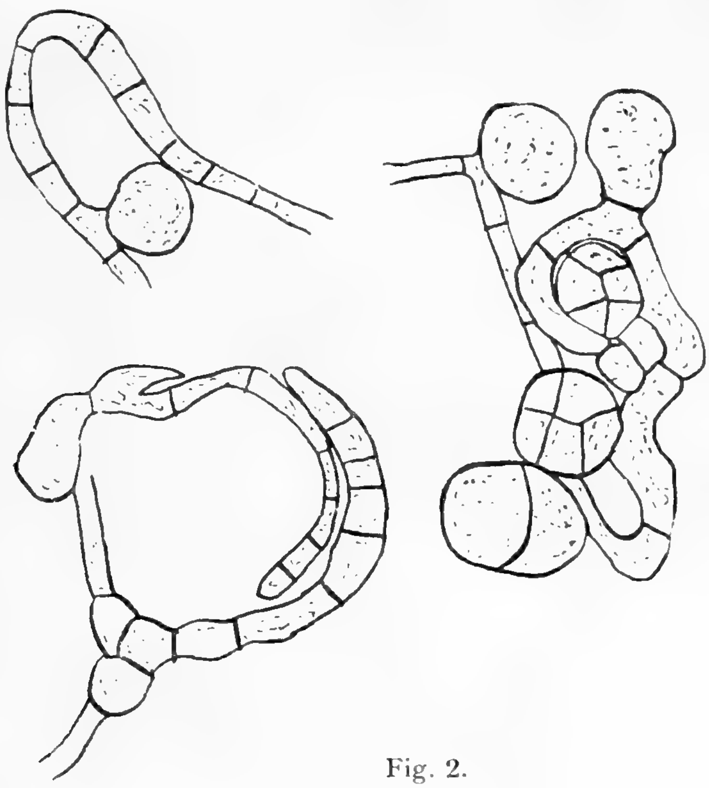


Fig. 2.

these buds, which at times are borne on a short stalk. These buds appear to become detached after they have increased considerably in size.

Hyphæ which enrol themselves were present, but were not observed in sufficient numbers to arrive at any conclusion. The enrolling observed (Fig. 2) appears to have much in common with the enrolling of the nodular swellings mentioned by Guéguen, though there is also evidence of the enrolling of hyphæ directly (Fig. 2). While the exact nature and object of this phenomenon is not known, it may be mentioned that they do not appear to have anything to do with the formation of the *Phoma* pycnidia.

The *Phoma* pycnidia, judging by the spore characters, evidently belong to *Phoma mali,* Schulz & Sacc. The spores are hyaline, unicellular, biguttulate, straight to slightly curved, and measure 5.6 to 7.36×2.76 to $3.8\ \mu$.

The pycnidia formed on media are usually circular or subcircular, and often more or less aggregated together (Pl. 34, *e*). Depressed pycnidia, more typical of *Phoma mali,* have also been observed.

Summary and Conclusion.

The paper contains certain cultural characters of *Coniothecium chomatosporum,* Corda, isolated from diseased apple-twigs, where the fungus produces a blister disease. On the fruit the fungus causes "russeting," and if infected while young, the fruit cracks, or under certain conditions withers and dies.

The fungus also occurs on the branches of pear trees, and isolation yielded results agreeing well with that described for the apple.

The *Coniothecium* developes between the cells. It invades the middle lamellæ, and as a result the cells separate, thus ultimately rupturing the skin and producing blisters or russet markings.

The cracking of the fruit, caused by infection with this fungus, must not be confused with cracking brought about by physiological causes.

The organism was isolated in 1913, and *Phoma* pycnidia formed abundantly in the original culture. Subsequently, by sowing only the *Phoma* spores, evidence was obtained that the *Coniothecium* condition is only a stage in the life cycle of the former—a view also advanced by Massee.

The cultural characters have much in common with those of *Coniothecium amentacearum,* Corda, as described by Guéguen, and had the investigation been completed, probably further resemblances would have come to light.

The *Phoma* which developed in cultures is *Phoma mali,* Schulz & Sacc., and hence *Coniothecium chomatosporum,* Corda, must be regarded as but a stage in the life circle of *Phoma mali,* thus agreeing with the view of Massee.

Our present knowledge of the genus *Coniothecium* does not warrant us to conclude that all the *Coniotheciums* will ultimately be related to the genus *Phoma,* and the subject is well worth further detailed investigation.

The *Phoma* pycnidia have also been observed on the host plants, though the *Coniothecium* stage is the more common in this country. The ascigerous stage—*Diaporthe ambigua,* Nits.—reported by Massee, has thus far not come to the notice of the writer.

The paper contains references to previous work as complete as possible from the publications at the disposal of the author, and for further references the reader is referred to Guéguen's work quoted.

EXPLANATION OF ILLUSTRATIONS.

The photomicrographs were taken with Edinger's drawing apparatus, and the drawings made with the aid of a Leitz drawing ocular.

Pl. 29, *a* Apples with "russet" markings.
b Blisters on apple twigs.
c Cracking in an apple.
d *Coniothecium* mycelium on an apple twig.
e *Phoma* pycnidia formed on Beerwort gelatine.

Pl. 30, *a* (600) *Coniothecium* stage on pear twig.
b (600) Section through blister. Note the *Coniothecium* spores.
c Original culture on beerwort gelatine from pear twig (seven days 20° C.).
d Grown on sterilised apple plugs (27 days 20° C.).

Pl. 31, *a* (440) *Coniothecium* stage from back of sterilised apple twig.
b (440) From mole grey growth on sterilised apple twig.

Pl. 32, *a* Pycnidia on prune agar (six days 20° C.).
b Pycnidia on sterilised bean leaf.
c (600) Section through pycnidium on sterilised bean stalk.
d Carrot agar (six days).
e Treacle agar (six days).
f Growth on—(1) Dox .4 per cent. gallic acid; (2) Dox .4 per cent. dextrose; (3) Dox .4 per cent. malic acid (February 7, 1914 to March 26, 1914).

Pl. 33, *a* (600) From Dox .4 per cent. gallic acid.
b (600) From Dox .4 per cent. gallic acid.
c (440) From Dox 1.5 per cent. dextrose.
d (440) From Dox 1.5 per cent. dextrose.

Pl. 34, *a* (440) From Dox 1.5 per cent. dextrose.
b (440) From Dox .4 per cent. malic.
c Original culture on beerwort gelatine from pear twig
d (440) From beerwort gelatine plate.
e (600) Section through pycnidia on cabbage.

Fig. 1 (800) Clamp connections and buds on mycelium from treacle agar (six days 20° C.).

Fig. 2 (800) Enrolling of hyphæ in greyish growth on sterilised apple twig.

NOTE.—The following allowances must be made for reductions made in reproducing the photographs of which the magnifications are given above:—

Plate *a* and *b* reduced $^4/_7$ (= × 340).
Plate 30 *a* and *b* reduced to ¾ (= × 330).
Plate 32 *c* reduced to ½ (= × 300).
Plate 33 *a* and *b* reduced to ½ (= × 300).
Plate 33 *c* and *d* reduced to ½ (= × 220).
Plate 34 *a*, *b*, and *d*, reduced to $^5/_{11}$ (= × 200).
Plate 34 *c* reduced to $^5/_{11}$ (= × 270).

A CRITICAL EXAMINATION OF THE METHODS USED FOR COUNTING IN ELECTIONS BY THE SINGLE TRANSFERABLE VOTE.

By John Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.

Synopsis.

Introduction.—This paper is written to demonstrate that the rules by which the votes are counted in all our Senate elections, and in all municipal elections in the Transvaal, do not secure the objects sought by Andrae Hare and John Stuart Mill when they advocated the use of the single transferable vote in Parliamentary elections, nor do they use the means they proposed.

These objects were, firstly, that every voter's vote should be made effective for the election of the member he most preferred, as far as possible; and secondly, that each member should be elected by, and so represent, the largest possible equal number of voters.

That number was $\frac{N}{n}$,—large N divided by small n, where large N is the number of voters and small n the number of members, and it divides the whole electorate into the n largest possible equal sections; and by the use of the transferable vote it enables every voter who marks his preferences on his ballot paper to the necessary extent to make sure that his vote, like every other voter's vote, will help equally in the election of the members.

The rules at present used divide the whole electorate not into n, but into $(n + 1)$ smaller sections, and thereby deprive the additional section of any share whatever in the election of the members; and in the case of very many of the other ballot papers which are used, fail to carry out the other voters' wishes as they have marked them at the poll. They are thus altogether incompatible with Hare's object, which was to make every single vote equally effective, in securing representation.

This is a very important matter, and I have to ask your close attention while I demonstrate these facts to you by the critical examination of the choices marked and used on the ballot papers in two actual South African elections, which, fortunately, I am able to show you.

1. *Object—To find the members most preferred by all the voters—Ten General Principles.*—In all elections the object is to choose out the members most preferred by all the voters.

(*a*) In all elections the getting of Droop's quota, one more vote than N divided by $(n + 1)$, secures the election of a candidate; and with the single non-transferable vote the elected candidate is proved to be one of the members most preferred by the voters, so far as the expression of one choice shows their preference.

(*b*) When votes can be transferred, election no longer proves that the elected candidate is one of the members most preferred by the voters. This can only be done, by alloting to each member Hare's quota, N divided by n, a larger number than that which elects the member, and in this way only can we get Proportional Representation, that is the equal representation of every voter by the member he most prefers.

(*c*) When a voter expressed only one choice he indicated the candidate he most prefers.

(*d*) If we give him the opportunity of expressing a second choice, that second choice may become equally effective as a vote, but it indicates a lower grade of preference than his first choice did.

(*e*) Each voter's vote, his ballot paper, is alike, and is entitled to similar treatment and to equal consideration, and the same is true of each grade of choice; but a first choice must be used, if possible, before a second choice, and so on grade by grade.

(*f*) This is the case with votes and choices for the same candidate, and also with those for different candidates.

(*g*) But where the voters have given expression to their preferences for different candidates, we can find out which are the candidates they most prefer only by giving effect to their first choices to the greatest possible extent before we make use of their second choices, and so on downwards, grade by grade.

(*h*) All elections are over as soon as the member with the fewest votes gets more than all the outstanding votes.

(*i*) Where the preferences of the voter are marked to enable his vote to be used, no vote of a grade lower than that at which the election can be finished should be used.

(*j*) To use a lower choice on a ballot paper than the highest that can be made effective is to fail to carry out the voter's wishes and directions.

2. *The Relative Majority*.—The usual method of electing town councillors or members of representative bodies in English-speaking communities is by the single non-transferable vote in wards or constituencies returning one or more councillors or members, who are elected by "a relative majority." In this method the quota, or number of votes sufficient to secure election, is a variable quantity in every election. It is one more than the number of votes obtained by the highest unsuccessful candidate. In almost every case the majority of the voters do not give an effective vote—that is, a vote that actually helps to elect the member. The votes made effective in this relative majority method are the very smallest number it is possible to use.

Where there are two candidates for one seat, as soon as the member secures a majority of one vote, all the additional surplus votes he receives do not help his election, are not effective votes. They are, so far as electing the member is concerned, as non-effective as are all the votes that the defeated candidate obtains. Thus, in every case where a majority of more than one is obtained, the member is actually elected by a minority of the voters. If A, the member, gets a large majority, say 68 votes, and the defeated candidate, B, gets only 17 votes, the number of effective votes that actually elect the member is 18, and 50 of his votes are non-effective, along with the 17 votes his opponent got. Sixty-seven of the 85 votes are non-effective. Where several members have to be elected, and there are many candidates, the proportionate number of non-effective votes is often very much larger.

3. *The Absolute Majority, and its Quota*.—This unsatisfactory condition is remedied, to a certain extent, in most European countries by adopting the Continental method of "the absolute majority system of election." In this system, where several members have to be chosen, second ballots are held for the election of those candidates, who at the original election do not secure the necessary number of votes. Thus the voters get another choice at a second election. This is a more satisfactory result, and a great improvement on that given by "the relative majority" method.

Yet here, too, a considerable number of the votes given are non-effective, especially when few members have to be elected. If one member has to be chosen, as in the case of the British Parliament, one more than one-half of the voters give effective votes, one less than one-half of the votes are non-effective. Where two members are to be elected, each must get one more

than one-third of the votes to secure election, and two less than one-third of the votes are necessarily non-effective. So if four members are to be chosen the quota is one more than one-fifth of the votes; the necessarily non-effective votes are four less than one-fifth of the votes.

If N represents the number of voters, and n the number of members to be elected, the quota under this system is $\frac{N}{n+1}+1$. This is the absolute majority quota.

It is generally known as Droop's quota by those interested in proportional representation.

Droop's quota can be used to find the members most preferred when the votes are all of one grade of choice; where only one choice has been marked by the voter, as in the case of the single non-transferable vote; or in cases with the transferable vote where the election is over on first choices only. In those two cases it correctly shows which are the members most preferred by the voters, for no transfers are made. Droop's quota is the smallest quota that can be used with a majority system of counting; for, if we diminish it by even one unit, we get the sum $\frac{N}{n+1}$, a sum which it is evident one more than n members could each get; for N is divided in $n+1$ equal parts. Thus it is evident that $\frac{N}{n+1}+1$ is the smallest possible majority quota. It is "the absolute majority" quota, and by it the smallest possible number of first choice votes and of second choice votes, etc., would be counted to the member. But to find out the members most preferred by all the voters, when they have the transferable vote, the largest possible number of first and other high-grade choices must be counted to them, as is only done when we use Hare's quota, N divided by n, which we have seen must be used to secure Proportional Representation.

4. *The Single Transferable Vote.*—In England in 1857 Hare published a system of voting, which had been introduced in Denmark two years before by Andrae, a famous mathematician. This system was afterwards very strongly advocated by John Stuart Mill. It is the system of the single transferable vote. Among its merits it secures:—

(*a*) That the largest possible number of votes, and of first and other high-choice votes, is allotted to and made effective for the selection of the members;

(*b*) That every voter has the opportunity of giving a vote which secures for him representation by the member he most prefers.

(*c*) That every member represents the largest possible equal number of voters; and

(*d*) That any section of voters large enough to give Hare's quota of votes can secure a representative, so that the elected representative body faithfully and exactly represents all the voters.

5. *The Quota.*—The quota with a majority system of counting must be such a number that all the members can obtain, and such that, when they do so, the remainder is less than a quota. We have seen that Droop's quota is the smallest possible. Hare's quota $\frac{N}{n}$ is the largest possible quota that can be used, for if you add but one unit to $\frac{N}{n}$ you get such a number that n members cannot each receive. If there are 10,000 voters, and ten members, Hare's quota is 1,000. If you add a single unit to it you get 1,001, a number which ten members cannot each get from 10,000 voters. The advantages of using it Hare secured, by giving the voters the privilege of marking on their ballot papers in the order of their preference, as many of the candidates as they chose. Hare gave the voter thus not only a second choice at another election, as the second ballot does, but as many choices as he chooses to mark. So that, if the candidate marked 1 cannot be elected by his vote, there is a chance given that it may help the election of the candidate marked 2, and so on successively. In this way every single vote can become effective, in securing representation.

The vote is equally effective for election and for representation whether it is used as a first choice vote or a second choice vote, and so on, but we must remember that the degree of preference it expresses is greater if it is used as a first choice vote than if it is used as a second choice vote, and still greater than if it is used as a third choice vote or one of lower grade.

6. *Necessity of Counting as many First Choices as Possible, and Treating alike each Grade of Choice on all Ballot Papers.*—Hence, when a voter has expressed these grades of preference, we can only carry out his wishes if we use as many first choices as we possibly can, and so with each successive grade; this we can do, of course, better by the use of the largest possible quota, which we have seen is Hare's quota. Droop's quota, admirable for counting votes in all cases, is able in elections by the single non-transferable vote, to point out the members most preferred by the voters. But it entirely fails to do so where votes can be transferred and where different degrees of preference are expressed by different grades of votes, as is the case with the transferable vote.

Mr. Humphreys* points out the necessity of using as many first choices as possible, and refers to this as "the principle adhered to throughout the regulations of giving effect to the

* Report on the Municipal Elections held at Pretoria and Johannesburg on 27th October, 1909, page 17, paragraph 52.

first and higher preferences before making use of lower preferences."

When we analyse a ballot paper with the voter's preferences marked upon it, A, 1; B, 2; C, 3; or A B C, "the effect of the voter's action," says Mr. Pim,* "can be stated as follows: 'I vote for A, and if my vote is not required or is useless for the purpose of electing A, I authorise the returning officer to use it for B. If not required, or useless for B, then he is authorised to use it for C, and so on.'" Every ballot paper is alike, therefore all must be handled alike, each grade of choice on every paper in exactly the same way and with the same consideration. Further, to carry out the voter's wishes, we must give effect to first choices to the greatest extent possible before we make use of second choices, and so on downwards. This is fundamental.

These two necessary principles are embodied by Mr. Pim in his fifth rule, which reads: "(5) As all first preferences are given effect to simultaneously in the first instance, so all the next succeeding preferences must also be given effect to simultaneously, and similarly with regard to later preferences."

When this rule is followed and Hare's quota is used, the members are elected on the highest possible preferences, and the election is over by the use of the highest possible grade of choices.

Choices are marked merely to enable the vote to be used; if a first choice on a ballot paper is made effective, no second choice on it need be looked at or considered. If an election can be finished on fourth-choice votes, no lower grade of vote can be used, and so on.

7. *Gregory's System of Correct Surplus Distribution.*—When a member gets a surplus of first-choice votes, as these votes are all of the same grade, all equal, each voter has the right to have an equal share of his vote used to give the surplus holder the quota. This is done when Gregory's method of surplus distribution is followed. The unused portion of each vote is called its "transfer value," because at this value it is passed on to the candidate marked second on the ballot paper. It is passed on, grade by grade, till it can be used.

The principle of the equality of every vote, whether a first choice vote or a vote transferred as a second, third, or tenth choice vote, is thus carried into effect. The use of Gregory's plan is necessitated by this principle—that every voter's vote must be treated alike. So much for the principle of the equality of every vote.

Another principle is also involved in Hare's method. Under it we no longer have one uniform class of vote, as in the cases where the single non-transferable vote is used, and counted either by "the relative majority" or "the absolute majority" method. We have now, with the transferable vote, first choice, second choice, third choice votes, etc., all equal, but each grade

* The Statistical Society of South Africa, Presidential Address, September 6, 1909, page 2, paragraph 9.

in due order downwards, entitled to priority in handling, and each grade expressing a greater degree of preference the higher it is. Our rules must provide that every first-choice vote must be counted and made effective if possible firstly; then every available second-choice on surplus votes and on votes for unsuccessful candidates must be simultaneously examined, and if possible, made effective before any third choices are examined, and so on. The second-choice surplus votes are fractional votes, the unused portions of each of the votes the surplus holder received.

8. *Humphreys' and Pim's Support of Heading* 6.—Both Mr. Humphreys and Mr. Pim, as we have seen, pages 662-3, point out that as many as possible of the first-choice votes, and of the successive higher choices, must be used if we are to carry out the voters' wishes. In this way only can we find out the members most preferred.

9. *Hare's Quota Necessary to Carry No. 6 out.*—No. 6 deals with "The necessity of counting as many First Choices as possible, and of treating alike each grade of choice on all Ballot Papers." This we can do only by the use of Hare's quota; by it alone can we make use of the highest possible number of first-choice votes and of the successive higher-choice votes. Hare's quota enables us to use more of these than we can do with Droop's quota; it enables us to use the highest possible number that can be used. Droop's quota makes use of the smallest possible number of these first and other high choices that can be used. It is by Hare's quota alone that we can, with the transferable vote, find out the members most preferred by the voters, which is the very first thing we have to do when preparing to count the votes in an election by the transferable vote. This is a work that has not to be done in elections by the non-transferable vote. In these elections we get the result at once by counting the votes by Droop's quota. With the transferable vote we must first allot the ballot-papers to the candidates best entitled to them. To do this we must use not Droop's, but Hare's quota, and in doing it we find not only which are the votes to which each candidate has a better right than any other candidate, but how many votes each candidate is entitled to, and which, therefore, are the members most preferred by the voters.

Just because by Droop's quota we find out the smallest possible number of votes that will elect each member, we cannot use it to find out the greatest possible number of first and higher choice votes each candidate can obtain, and this is the information we must have to find out who are the members most preferred by all the voters, and to secure Proportional Representation.

With Droop's quota the largest possible number of votes are non-effective, and take no part in electing the members. With Hare's quota the smallest possible number of votes are not counted, and are not given to the member who has more right to them than any other candidate.

10. *To Carry Out the Voters' Wishes, the Highest Choice Possible Must be Used.*—Whenever a higher choice on a ballot paper for one candidate is passed over, and a lower choice on it is used or counted to another candidate, that voter's wishes and directions have not been carried out as he marked them on his ballot paper, and as many as possible of the highest available choices must be counted.

11. *How Droop's Quota Fails to Carry Out the Voter's Wishes.*—When Droop's quota is used for primary surpluses, we stop counting first choice votes for the member as soon as Droop's quota is reached, and (1) on all his ballot papers up to the point where Hare's quota is reached we use second or lower choice votes for other candidates in place of the first choices we use if Hare's quota is employed; and in every one of these cases we fail to carry out the voter's expressed direction.

(2) In all cases where these lower choices help to elect a member, we possibly prevent other voters who have marked higher choices for that member having these choices counted, and necessitate lower choices on their ballot papers being used for another candidate.

(3) With Droop's quota more members get surpluses, and choices for these surplus holders have to be passed over on other voters' ballot papers, and this necessitates the use of lower choices.

(4) With Droop's quota the necessarily non-effective votes are at a maximum; there are thus fewer votes that can be counted to or allotted to a member than with Hare's quota, and this necessitates the use of lower choices.

Hare's object was to use and count to each member in every election the maximum number of votes, every vote without exception, thus securing Proportional Representation. Droop's object is to count the absolute minimum number of votes that will give each member a majority of one vote. Its use is therefore absolutely inconsistent with Hare's object.

It is quite true that Droop's quota shows the minimum number of votes that will secure the election of the members; and where the non-transferable vote is used, or where with the use of the transferable vote there are no transfers because the election can be finished on first choice votes, Droop's quota also shows which are the members most preferred by the voters. But when, as Hare suggested, the transferable vote is used to secure the efficiency of every vote the use of Droop's quota is utterly inconsistent with securing Proportional Representation. It is not only useless, but harmful, because with its use all the voters cannot help in the selection of the members most preferred by the voters for the choices marked on each of the ballot papers of a section of the voters nearly equal in numbers to Droop's quota cannot be used, their wishes cannot be carried out, they take absolutely no part in the selection of the members. Not only so, but in the case of the ballot papers of all voters in the other n sections which are used and counted,

the use of Droop's quota frequently causes lower choices on these ballot papers to be used for certain candidates, whilst higher choices for other members are passed over on the same ballot paper. Hence the voter's wishes are in many cases not carried out as they marked them. This I shall show in the case of ballot papers used at two actual elections. Thus it is it fails to show who are the members most preferred by all the voters.

To sum up the case against the use of Droop's quota—

(*a*) By adopting Droop's quota you use Hare's proposal of the transferable vote to carry out elections by the absolute majority, the very system Andrae, Hare, and Mill wished to supersede.

(*b*) You always infallibly disfranchise certain voters, and in the election of the members ignore and make no use of the choices marked on ballot papers to the number of $\frac{N}{n + 1} - n$, votes.

(*c*) In all cases of surplus holders who get more than Droop's quota, you of necessity fail to use first-choice votes, or other higher-choice votes to which those members have the best right, and which with Hare's quota they can use, and you employ second or lower choices on these ballot papers for other candidates. In many cases you use as votes choices of a lower grade than that at which the election can be finished, when all available higher choices are counted for other members or candidates in accordance with the wishes of the voters.

(*d*) You sometimes elect members on these lower choices, while other candidates could have secured election on higher choices.

(*e*) You always, in every election where transfers are made under Droop's quota, make effective for other candidates votes that might on higher choices have helped the selection of another member who had a better right to these votes, and in one example of an actual election, which I shall show you, you do this on every one of the ballot papers which are transferred. You never can be sure that you have elected the members most preferred by the voters.

12. *Members can be Duly Elected Without Getting the Quota.*—In every system of counting votes the quota secures the election of the member who gets it, but it is not necessary that every member should get the quota. With Hare's larger quota it is much more rare for all the members to get it than with Droop's. In most elections with either quota the lowest or a few of the lower members are elected without obtaining the quota.

13. *What Finishes Every Election.*—All elections are necessarily finished as soon as the member with the lowest number of votes gets one more than all the outstanding votes. This fact is recognised officially by Rule 9 (3) of the Municipal Representation Bill Rules (see "Proportional Representation," page 348,

by John H. Humphreys: Methuen; crown 8vo., price 3s. 6d. net).

If 1,000 voters are electing four members from five candidates, the election is over without any member getting Hare's quota, if they receive respectively:

239, 230, 220, 210, 101 votes = 1,000; or
239, 230, 220, 156, 155 = 1,000.

The election is over as soon as the fourth member gets one more than all the outstanding votes.

Hence, in any accurate system of counting in elections with the transferable vote, we must have the means of seeing at what grade of vote the election can be finished; for, as mentioned before, no lower grade of choice than that at which the election can be finished in accordance with the voters' wishes ought to be used. The rules for the election of the Senate give no information on this point, and in every election under them choices lower than ought to be used are made effective, and sometimes elect a member. In three elections in South Africa by the transferable vote, an examination of the votes used shows that one of the candidates not elected was more preferred by the voters than one of the members who were elected by the present rules on lower choice votes than those on which the election could be finished if Hare's quota was used.

14. *Requisites for a Correct System of Counting.*—Bearing in mind the previous facts, we can now lay down the lines on which a correct system of counting in elections by the transferable vote must be conducted, if we wish to secure Proportional Representation.

At the first count we must have the simultaneous examination of all first choices on all ballot papers—exactly as in all other elections, whether by "the relative majority," "the absolute majority," the Senate rules, or any others. All members who get Hare's quota $\frac{N}{n}$, or a surplus, are finally elected. These first choices, or the share of them necessary to give the surplus-holder Hare's quota, have secured their share of representation; and no subsequent operations can in any way affect them. They comprise the largest possible number of first-choice votes that can be used.

At the second count, every available second choice must be simultaneously examined and distributed to the elected members, the continuing members, and the unsuccessful candidates, marked second on the ballot papers just as was done at the first count. The distribution of all these second choices, and of all succeeding lower choices, must be entered on the transfer sheet.

The available second choice votes are the unused fractional portions of all first choice surplus votes, and the whole choices on the ballot papers received by the candidates unsuccessful at the first count.

If at the end of this second count any continuing member secures Hare's quota, he is not finally, but only tentatively, elected; for some of the second choices which he receives from an unsuccessful candidate may have come from one who will be found, before the end of the election, to be entitled to election; in that case, these second choices must be withdrawn and recounted as first choices for him, and this may leave the candidate to whom they have been credited temporarily at this second count unelected.

Hence, after the first count, no member is elected, no vote is finally transferred, till the result sheet shows that the election can be finished, and shows, too, who are the candidates who can secure election on the highest choices. Then, and not till then, is any transfer of the vote made. As soon as the distribution of all available second choices has been made, we must look carefully at the result sheet, to see whether any candidate, unsuccessful at the first count, could receive more first and second choices than the lowest of the continuing members. If this is the case, the former must replace the latter, and the counting must be carried out from the distribution of the unsuccessful candidate's second-choice votes with a new classification of continuing members and unsuccessful candidates.

Only after this has been done can the third count of the available third-choices be begun. If, at their distribution, or at any later count, a displacement of a continuing member occurs, the above proceeding must be followed out, and a new result sheet of the distribution of all unsuccessful whole choices made.

It is only when this course is followed that the voter's wishes, as they express them at the poll, are carried out to the fullest possible extent.

By the use of Mr. Pim's fifth rule and Hare's quota we can secure the following results:—

(*a*) We use the greatest possible number of first and higher choices;

(*b*) We show at what grade of vote the election is over;

(*c*) We use no lower choices than are absolutely necessary;

(*d*) We elect the members most desired by all the voters; and

(*e*) We reduce the non-effective votes to a minimum.

15. *Recapitulation.*—Droop's quota is advocated by Mr. Humphreys; it is advocated by Mr. Pim; it is used in all the authorised plans of counting; it elects all our own Senators and all the members of all the Municipal Councils in the Transvaal. This is my reason for recapitulating the facts I have found from the examination of the results of its use in many actual elections.

Where the votes to be counted are uniform, are of one grade, where no votes can or need be transferred, it accurately counts all the effective votes and elects the members most preferred by the voters.

Where, in place of the limited expression of the voters' preference that is possible when each voter marks one choice only, we can get the opinion of every voter as to the order of his preferences for the members he most prefers by means of the use of the transferable vote, Droop's quota fails to indicate the members most preferred by the voters. This can only be done when we make use of Hare's quota, by which alone we can, to give Mr. Humphreys' own words, "give effect to the first and higher preferences before making use of lower preferences" to the largest possible extent. We can do this, because Hare's quota is the largest possible quota that can be used. In this way only, by the use of Hare's quota, can Mr. Pim's fifth rule, on which a correct system of counting must be founded, be carried out.

The transferable vote gives us grades of preference—a new feature. First-choice votes express a higher grade of preference than second-choice votes, second-choice votes a higher grade of preference than third-choice votes, and so on. To make use of the grades of preference thus expressed by the voters at the poll, we must make use, to the utmost possible extent, of all the first-choice votes firstly before second-choices are considered, and so on successively, with each grade of choice. Under these circumstances, Droop's quota no longer elects the members most preferred by the voters. It is therefore inadmissable: it is inconsistent with the use of the transferable vote—it fails to show the members most preferred—when by the transferable vote the voters express fully their preferences.

The highest number of votes a member can obtain is Hare's quota—the highest number all n members can each obtain. In this paper I have pointed out that in all rules of counting, where Droop's quota is used to transfer the votes, we can only say that certain members are elected by the Continental plan of the absolute majority of one vote, but that we have no certainty that these are the members most preferred by the voters. I have shown that this was the very system Andrae, Hare, and John Stuart Mill wished to supersede by the use of the transferable vote, which enables every voter to help in the selection of the member he most prefers. I have demonstrated that the use of Droop's quota is utterly inconsistent with this object, and affords no security that the wishes of the voters marked on their ballot-papers are carried out, and is inconsistent with securing Proportional Representation.

I have shown that by the use of Hare's quota, Gregory's system of surplus distribution, and Mr. Harold Pim's method of the simultaneous distribution grade by grade of all available choices as marked by the voters, their wishes can be carried out exactly as they marked them with impartiality, certainty, accuracy, and despatch.

I have drawn up a set of suggested rules which will, I believe, secure these results; and I give here the working out of two elections under both systems, and a table of choices in

the smaller election, by which the truth or fallacy of the facts I have pointed out can be demonstrated.

16. *Defects of the Senate Rules.*—Under the Senate rules we find the following defective conditions:—

A. There is no giving effect to all second-grade and lower-grade choices simultaneously.

B. There is no indication of the grade at which the election can be finished.

C. The smallest possible number of first and higher choices is made effective through the use of Droop's quota.

D. (*a*) There are consecutive distributions of each candidate's votes in a prescribed order

(*b*) And in each case all available choices, however low, are at once made effective, so that the voters for no two candidates are treated alike, and many lower choices are improperly made effective.

E. (*a*) All the unsuccessful candidates except the highest are successively excluded, and

(*b*) All further choices marked for them are by rule directed to be ignored.

(*c*) No record is kept of the choices marked for excluded unsuccessful candidates, so no evidence of a displacement can be obtained.

(*d*) The original and transferred votes of the highest unsuccessful candidate are not further examined, distributed, or used.

F. Hare's plan of the transferable vote is used to conduct an election with the quota $\frac{N}{n+1} + 1$, the quota used in every election by "the absolute majority"—the very system Hare aimed to supersede by the use of the transferable vote, and the division of the whole electorate into n sections.

G. Neither of the two principles, advocated by Mr. Humphreys and Mr. Pim, are carried out. The votes are not handled alike, nor is effect given to the highest choices as far as possible. The members elected under the Senate rules are those who obtain a majority of .01 of a vote, when on a section of the votes equal to one more than N divided by $n + 1$ all the choices marked for them, however ldw, on a single arrangement of ballot papers, are successively counted as effective votes. These members are not necessarily those most desired by the voters, and at every election under the Senate rules votes of a grade lower than that at which the election could be finished are used, and sometimes elect members less preferred by the voters than one of

the rejected candidates. Hare's object was to secure representation for every voter by the use of every vote; this can only be got by the means he proposed—dividing the electorate into n equal sections. With Droop's quota they are divided into $n + 1$ sections. The two plans are incompatible. The two objects are different. Droop's object is the election of a member. Hare's object is the representation of every voter.

Before we count the votes at an election with the transferable vote, we must allot to each candidate those ballot-papers to which he has more right than any other candidate.

To find out the candidates most preferred by the voters we must count the utmost possible number of first and other high choices for each member, and this we can only do by the use of Hare's larger quota. If the number of votes a member gets exceeds Hare's quota, we cannot give that member the full value of all his votes, because, that would leave too few votes to give all the members Hare's quota; but Hare's quota enables us to give to each member the greatest possible number or value of these first-choice votes, or of these higher votes that the member gets.

If we use Droop's quota to select or find out the members, we stop counting these first or higher votes as soon as we have reached the number, that will give each member Droop's quota in place of the highest possible number. That is, we stop allotting first-choice votes as soon as we have reached the very smallest possible number, which will give the member one more vote than $n + 1$ candidate could obtain, in place of the highest possible number that can be made effective,—Droop's quota is a totally different number from that which will make plain who are the members most preferred by the voters: which is the whole object of the use of the transferable vote, and of every election. If at an election the votes are allotted by Droop's quota, we never can get proportional representation.

17. *Cape Hospital Board Election,* 1915, *under Senate Rules, and under Suggested Rules. Comparison of Results.* —We will now examine this election carried out under the suggested rules and under the Senate rules, noting in the case of the transfer of the votes in each method the grade of vote we transfer.

At the Cape Hospital Board election for the year 1915, 658 voters elected four members from six candidates under the Senate rules with Droop's quota of 132, while Hare's quota is 164.

The election under the suggested rules is completed by the examination of all available second-choice votes, and to it, under these rules, I shall first direct attention.

Cape Hospital Election, 1915.

658 voters elect 4 members from 6 candidates.

The Result Sheets give the Values of Votes.

Under Suggested Rules, Quota 164.

I.	II. A–50	III. E60	IV. F42	V. Effective	VI. Non-effective
A214		11	1	164	12
B149	2	10	4	164	1
C123	40	23	9	164	31
D 70	4	14	21	109	
E 60	3		7		10
F 42	1	2			3
658	50	60	42	601	57
				658	

Explanation of the Suggested Rules Table.

In Column I we have the first-choices marked for the five candidates. In Columns II, III, IV we have respectively the values of the shares of A's surplus votes and of E's and F's votes, which the other candidates receive on the simultaneous distribution of all available second-choices. In Columns V and VI we have respectively the total effective and the non-effective votes, using the word "effective" in the sense of effective in securing representation.

Under Senate Rules, Quota 132.

VII.	VIII.	IX. A	X. B	XI. C	XII. F	XIII. Effective	XIV. Non-effective
A214		–82			42	132	
B149			–17			132	
C123	2nd	67		–58		132	
D 70	2nd	6	3		21		
	3rd	1	2	28	4	132	9
	4th		1	3	2		
E 60	2nd	4	3		7		
	3rd	1	3	16	3		102
	4th		1	3	1		
F 42	2nd	2	2				
	3rd		1	6			13
	4th			2			
Exhausted					4		4
Lost by fractions		1	1				2
658		82	17	58	42	528	130
						658	

EXPLANATION OF THE SENATE RULES TABLE.

In Column VII we have the first choices, as in Column I. In Column VIII on separate lines we have the grades of the votes received by each candidate, so that we can compare the two methods: at the actual election there is, for example, only one entry of the value of six votes received by D from B, with no specification of the grade of each. Column VIII enables us to see that three were second-choice votes, two third-choice votes, and one fourth-choice vote. In Columns IX, X, XI, and XII we have respectively the distribution of the values of the three surpluses and of F's votes to the candidates. Under Senate rules, E's 60 votes are not distributed. E receives the value of 67 second choice votes from A's surplus in addition to 123 first choice votes. This gives E a secondary surplus of 58 votes distributed in Column II. Column XIII gives the effective votes, and Column XIV the non-effective, non-effective for election purposes, or representation, or for selecting the members most preferred by the voters.

COMPARATIVE RESULTS.

Suggested Rules.			*Senate Rules.*			
Effective Choices. 1st	2nd	Non-effective	Effective Choices. 1st	2nd	3rd	Non-effective
A 164		A 12	132	C 9	D 32	D 9
B 149	15	B 1	132	D 30		E 102
C 123	41	C 31	123			F 13
D 70	39	E 10	70	39		Ex. 4
		F 3				Fr. 2
506	95		457			
95		57	39			130
			32			
601	+ 57	= 658	528	+ 130	= 658	

49 fewer 1st Choice Votes.
56 fewer 2nd Choice Votes.
32 more 3rd Choice Votes.
73 more Non-effective Votes than under the Suggested Rules.

EXPLANATION OF THE COMPARATIVE RESULTS.

We see that with Hare's quota, 164, and the suggested rules, the four members are elected in exact conformity with the first and second choices marked on the ballot-papers, 506 first choices being used, and 95 second-choices on the other ballot-papers, with 57 non-effective votes; 32 of these are surplus votes, which have helped in the election of B and C; 12 are non-effective second-choice votes for A. Of the remaining 13, 4 are from A's surplus, Column II, and the others are 7 votes marked F E, and 2 marked E F. These 9 voters are the only voters not represented by the members marked first or second on their ballot-papers, and each of them had marked the member he most preferred as his third choice, and

would have helped to elect him had he not already secured election on first or first and second-choice votes.

Under Senate rules 457 first-choice in place of 506 are used; 39 second-choice votes in place of 95: and 32 third-choice votes; and the value of the non-effective votes taking no part in the election are 130, as compared to 57, that is 73 fewer.

Under Senate rules 35 third-choice votes for D, 23 for E, and 7 for F, or 65 in all, along with 13 fourth-choice votes, 78 in all, are counted for the candidates, not one of which need have been looked at, much less counted, if E's original 60 votes had been distributed. E's original 60 votes, with the 42 votes transferred to E, and 28 other votes, take no part at all in electing the members.

As the election can be finished on second-choices, there is no need to look at, much less to count, third or fourth-choices. Yet we see that under Senate rules there is only one single transfer of second-choice votes alone of two votes marked A F in Column IX. On every other transfer on the sheet third-choice or third and fourth-choice votes are counted to the value of 78 votes; not one of which need have been looked at, much less counted.

Owing to the use of Droop's quota under the Senate rules we have—

(*a*) Three surpluses of the value of 157 votes in place of one of 50 votes.

(*b*) Forty-nine first-choice votes from A and B are distributed as second, third, and fourth-choice votes to other candidates, which can be used as first-choice votes in accordance with the voters' wishes.

(*c*) Of the 363 votes received by A and B, a smaller share, amounting in all to 49 votes, was retained as first-choice votes for these two members.

(*d*) Second-choice surplus votes for C, of a total value of 58 votes, were distributed as third and four-choice votes.

In addition to these defects, we have, as in every election under the Senate rules—A, no simultaneous distribution of second and lower choices; B, no indication of the grade of vote at which the election can be ended; D, consecutive distributions in a prescribed order, with the use at each of all available choices, however low their grade; E, the exclusion of all but the highest unsuccessful candidate, the ignoring of choices marked for him, no record of choices given to unsuccessful candidates (here I have marked their grade for purposes of comparison), and no distribution of the highest unsuccessful candidate's ballot papers, either those originally given to him or those transferred to him.

Column III shows that E's votes, which are not distributed under Senate rules, give 10 second-choices to B, 23 to C, and 14 to D from his original 60 votes, to say nothing of the lower choices on the 37 second and third-choice votes he gets under the Senate rules.

In spite of all these defects, it happens that the same four members are elected under both methods. It is not always so, as we shall now see.

18. *Illustration of a Displacement. Temporary Result Sheet.*

ILLUSTRATION OF A DISPLACEMENT IN A TRANSVAAL SENATE ELECTION.

84 *Voters elect 8 Members from 13 Candidates. Quota* 10.5.

TENTATIVE: UNDER SUGGESTED RULES.

	Distribution of Whole Votes given to Unsuccessful Candidates counted on Grades.					Distribution of 3rd and 6th Choices on Members' Surplus Votes.									
	First	2nd	3rd	4th	6th	Third			Sixth Choices.						
	I	Column II				III	IV	V	VI	VII	VIII	IX	X	XI	XII
		12				HJC	HMC	BA	HJM	HJC	HMC	BAC	HA	Effective.	Non-effective.
						.75	.5	.25	.75	.5	.34	.16	.25		
G	10													10	
J	10	2			1									10 5	
M	10	1			1	.75								10.5	
K	10													10	
I	1	2										.16			.16
B	1	3		1	1				.75		.34	can get			7.09
A	9	2												10.5	
C	9	1			1	.75	.5	.25					.25	10 5	1.25
E	2		1												
D	2	1			1					.5					.50
F	7													7	
H	6														
L	7		1											7	
		12												76	9

NOTE 1.—Three votes, 21, D I M A C B; 22, E I A J M C; 47, I D E B, appear in the column headed 2nd as non-effective votes for I I D as 2nd choices, Column II, 2nd, before their final appearance for B, C, B respectively in Column II, 4th and 6th.

NOTE 2.—When one candidate displaces another, as in the instance above B displaces F and L, because he can get 7.09 votes, while F and L can only get 7 (see Columns XII and XI), the first result sheet which shows this is a tentative or temporary one; and we have a second or final result sheet, in which the displaced member (in this case L) has his ballot-papers distributed along with those of the other unsuccessful candidates.

EXPLANATION OF THE ABOVE TABLE.

This is more complicated than the Hospital Board election, but more interesting and instructive. In Column I we have, as before, the first-choices for each candidate.

In Column II we have four lines headed 2nd, 3rd, 4th, 6th, of different grades of choice; and the 12 whole votes of the five candidates unsuccessful at the first count are tentatively distributed as second-choice votes. J gets 2, but needs only .5; so .25 of each is retained, and 2 votes, H J C and H J M, are left, each of the value of .75. Columns III and VI. M gets 1 and needs .5; so the votes H M C is left with the value .5, Column IV. A gets 2 votes, B A, H A, he needs 1.5; so they are each left with an unused or transfer value of .25, Columns V and X. C gets and keeps 1 vote D C. I gets 1 vote, 21, D I M A C B, non-effectice as a second-choice vote for I, but which becomes effective as a sixth for B; and one vote, 23, E I A J M C, is non-effective for I, and also at the sixth count for C. D gets one vote; vote 47, I D E B, which becomes available as a fourth-choice vote for B.

In Columns III, IV, V, third-choices are dealt with; one non-effective goes to M, who is already elected, vote 45, H J M C A B, .75, and three H J C, H M C, B A, go to C, of the values .75, .5, .25, or 1.5 in all. C needs .5, so retains one-third of each, leaving transfer values to two places of decimals of .5, Column VII; .34, Column VIII; and .16, Column IX.

At the distribution of whole third-grade votes, vote 47, I D E B goes to E as a non-effective third-choice vote, and vote 22 goes to L, E B L.

The votes that go at these distributions to elected members are passed on for distribution at the next count. All others are entered, so that we can see how many votes each continuing member or unsuccessful candidate can get. At the fourth count only the vote 47, I D E B, goes as an effective vote to B. No transfer is made at the fifth count.

At the sixth count, Column II, J, M, C, D, get non-effective whole votes, and B gets a vote. Columns VI and VIII give B .75 and .34, so he *can* get 7.09. I gets .16, Column IX; C gets .25, Column X; and D .5, Column VII.

NOTE 3.—Vote 10, B A C M J I, gives .75 to A, Column II, 2nd, and .09 to C, Column V, and .16 to I, Column IX = 1, none of which should be counted; for in Column I it is counted to B. So the real total effective votes are 76 − .84, or 75.16, and the non-effective are 9 − .16 = 8.84; 75.16 + 8.84 = 84. The vote E B L is counted to B, so L has only his original 7 in Column XI.

As B can get 7.09 votes and F has only 7, he displaces F, and a new second count must be made with B retained as a continuing member. When E B L goes to B, not L, L, too, has only, like F, seven original votes. So the lot must be cast to show whether L or F have their votes distributed. It falls on L, whose second choices must be distributed with those of H, E, D, I, 18 in all at the first distribution, Column II, second on the final result sheet.

Transvaal Senate Election.

List of choices marked on the 84 Ballot Papers.

	1	2	3	4	5	6	7	8	9	10
1 ..	A	B	C	J	E	M	I	D	L	H
2 ..	A	B	C	J	M	I	D	E	L	H
3 ..	A	B	C	M	J	D	H	I	E	L
4 ..	A	B	C	M	J	D	H	I	E	L
5 ..	A	B	D	C	J	M	H	I	E	L
6 ..	A	B	M	J	C	I	D	H	E	L
7 ..	A	H	B	D	J	C	M	I	E	L
8 ..	A	H	C	D	B	I	M	J	E	L
9 ..	A	M	C	D	J	B	H	I	E	L
10* ..	B	A	C	M	J	I	D	H	E	L
11 ..	C	A	J	M	B	D	E	H	I	L
12 ..	C	A	J	M	B	D	I	E	H	L
13 ..	C	B	A	J	M	D	E	L	I	H
14 ..	C	B	A	M	J	I	D	E	H	L
15 ..	C	B	D	A	E	H	I	J	M	L
16 ..	C	B	E	A	M	D	I	J	H	L
17 ..	C	B	M	A	H	D	I	J	E	L
18 ..	C	H	M	A	J	B	D	I	E	L
19 ..	C	J	A	I	M	B	D	H	E	L
20* ..	D	C	H	I	B	E	J	A	L	K
21* ..	D	I	M	A	C	B	H	J	E	L
22* ..	E	B	L	H	M	J	I	C	D	A
23* —	E	I	A	J	M	C	D	B	H	L
24 to 29	F									
30 ..	F	G	K							
31 to 34	G	K								
35 to 39	G	K	F							
40 ..	G	K	F	L						
41 ..	H	A	M	J	D	C	B	E	I	L
42 ..	H	B	A	C	M	J	D	I	E	L
43 ..	H	B	J	C	A	D	I	E	M	L
44 ..	H	J	C	A	M	D	I	E	B	L
45 ..	H	J	M	C	A	B	D	I	E	L
46 ..	H	M	C	J	A	B	D	E	I	L
47* ..	I	D	E	B	J	M	A	C	H	L
48 ..	J	B	H	A	C	M	D	E	L	I
49 ..	J	B	L	M	A	C	E	I	D	H
50 ..	J	B	M	A	C	E	D	I	H	L
51 ..	J	C	M	A	D	E	I	B	H	L
52 ..	J	E	B	C	A	M	I	H	D	L
53 ..	J	E	L	H	C	D	A	B	I	M
54 ..	J	E	M	C	A	I	H	D	B	L
55 ..	J	H	A	M	C	B	D	I	E	L
56 ..	J	H	C	M	A	B	D	I	E	L
57 ..	J	I	A	B	C	D	M	H	E	L
58 to 63	K	G	F							
64 ..	K	G	F	J	H					

	1	2	3	4	5	6	7	8	9	10
65 ..	K	G	J	L	C	E	D	M		
66 ..	K	G	L	C	J	M	A	H		
67 ..	K	G								
68 to 72	L									
73 ...	L	B								
74 ..	L	B	C	A	D	E	H	I	J	M
75 ..	M	B	A	J	I	C	D	E	H	L
76 ..	M	B	J	C	A	D	E	I	H	L
77 ..	M	C	B	A	J	I	D	H	E	L
78 ..	M	D	I	A	J	C	B	H	E	L
79 ..	M	H	C	A	B	L	D	J	E	I
80 ..	M	H	J	C	A	D	B	I	E	L
81 ..	M	E	A	B	C	H	J	D	I	L
82, 83	M	E	B	C	A	J	H	D	I	L
84 ..	M	J	E	C	B					

NOTE.—Six votes marked * are the six whole votes transferred under Senate Rules, page 682.

19. *Final Result Sheet under suggested Rules.*

84 *Voters elect* 8 *Members from* 13 *Candidates. Quota* 10.5.

	First. I.	Distribution of Whole Votes given to Unsuccessful Candidates counted on Grades. Second Column II. 2nd	3rd	4th	6th	Distribution of 3rd and 6th Choices on Members' Surplus Votes. Third Choices. III.	IV.	Sixth Choices. V.	VI.	VII.	VIII.	IX. Effective	X. Non-effective.
		18				HJC	HMC	HJC	HJM	HMC	EIA		
						·75	·5	·45	·75	·3	·5		
G	10											10	
J	10	2										10·5	
M	10	1										10·5	
K	10											10	
I	1	2											
B	1	5		1	1				·75	·3		9·05	
A	9	1	1									10·5	
C	9	1				·75	·5				·5	10·5	·5
F	7											7	
L	7												
H	6												
E	2		1										
D	2	1						·45					·45
Exhausted		5											5
		18										78·05	5·95
												84	

EXPLANATION OF THE ABOVE TABLE.

In Column II, 2nd of the new final result sheet the changes owing to the distribution of L's votes are very simple: two votes, LB, go to B as second-choice votes, giving him five in puace of three, JB and the other five votes are exhausted. The vote BA, being retained as a first-choice vote for B, no longer goes to A, who thus gets only one second-choice vote, HA, in place of the two BA and HA which he got before. Votes 47 and 20 go to B in Column II, 4th, and 11, 6th, respectively.

At the third count, Column II, 3rd, A gets the third-choice vote 22.EIA; this gives him the quota, and leaves that vote = .5, Column VIII. L, of course, loses the vote EBL, which has gone as a second-choice vote to B. Columns III and IV are as before, but the old Column V is gone, as the vote BA, which went as a third-choice vote to C, is now retained for B. At the new third count, Columns III and IV, C needs .5, and gets from HJC .75 and from HMC .5, together 1.25. Two-fifths of this is .5; so two-fifths of each of these two votes are retained for C, which leaves HJC .45, Column V; and HMC .3, Column VII.

At the fourth and fifth counts, no changes are made.

At the sixth count B gets one vote, Column II, 6th, from vote 21, DIMACB; and ·75 and .3 in Columns VI and VII. D gets .45 in Column V; and C gets .5 in Column VIII.

This finishes the election on sixth-choice votes, in exact accordance with the voters' wishes. Five votes, plumpers for L, were exhausted. Of the other 79 all were effective in helping to elect the members, except the value of .95 on two votes for C and D, one of which, vote 23, helped to elect A, the other 44 helped to elect both J and C. The elected members are G, J, M, K, A, C, B, F. Vote 23, E I A J M C B D, .5, and Vote 44, H J C A M D I E B, .45, at the eighth and ninth choices respectively both go to B, giving him 10 votes, and concentrating all the available 79 votes on the 8 members; 5 votes were plumpers for L, an unsuccessful candidate. This gives us proportional representation as far as the marking of the ballot papers allow.

We shall now examine the same election carried out on Senate rules:—

20. *Same Election under Senate Rules, when every Transferred Vote is transferred in part or whole as a Lower Grade Vote to another Candidate than one marked on the same Ballot Paper to whom it is counted under the Suggested Rules, and 9.28 votes can take no part in electing the members, or in securing Representation, and two other members, H and L, are in consequence elected on 7th, 8th, 9th, and 10th choice votes in place of B and F.*

THE SAME ELECTION UNDER SENATE RULES, WITH THE GRADE OF EACH TRANSFERRED VOTE SPECIFIED.

84 Voters elect 8 Members from 13 Candidates. Quota 9·34.

Consecutive Distributions of all Available Choices.

			Primary Surpluses.				Votes.		Surpluses.		Votes.			
I.	II.	III.	IV. G ·66	V. J ·66	VI. M ·66	VII. K ·66	VIII. I 1·07	IX. B 1·35	X. A ·73	XI. C ·74	XII. E 2·49	XIII. D 4·81	Effective.	Non-effective.
G 10	9·34		—·66										9.34	
J 10	9·34			—·66									9·34	
M 10	9·34				—·66								9·34	
K 10	9·34					—·66							9·34	
A 9		2nd						1	—·73				9 34	
		3rd					·07							
C 9		2nd		·07	·07									9·34
		3rd							·73					
		4th						·07		—·74				
		5th						·07						
		6th						.07						
E 2		2nd		21	·07									
		3rd			·21									
D 2		2nd			·07		1							
		7th								·74	1			
I 1		2nd		·07										
B 1		2nd		·21	·14									
F 7		2nd	·66			·49								8·15
H 6		2nd		1·14	·14								9·34	·43
		3rd						·07				1		
		6th									07			
		7th				Eletced on four 7th,					·21	1		
		8th				two 8th and					·07	·07		
		9th				one 9th choice votes.						1		
L 7		3rd				·07		·07			1·07		9·34	·60
		4th				·07								
		10th				Elected on two 10th choice votes.						1·74		
		Exhausted				·07					·07			·14
		Gain		·04	·04	·04 = ·12							74·72	9·40

Elected G J M K A C H L. Unsuccessful D E I F B. 84·12
Gains ·12

NOTE.—The Senate rules elect L and H, two candidates very little preferred by the voters; for the Table of Choices clearly shows that 29 of the 84 voters marked no choice for either of them and of the remaining 55, 38 marked L as their 10th choice; and 30 marked H as their 7th, 8th, 9th, or 10th choice. The faults arise from the use of Droop's quota 9.34 to allot the votes. When all 8 members get Droop's quota, 74.72 are used up, and 9.40 are left; of which .12 is a gain from counting the transfer value of 30 surplus votes for J, M, and K, see last entry in Columns V, VI, and VII, at .07 in place of .066. So subtracting .12 from 9.40, we get 9.28 votes left; which, owing to the use of Droop's quota, can take no part in electing the 8 members, and get no share of representation. The voters who gave these 9.28 votes are, in so far as those

votes are concerned, totally unrepresented by the 8 members elected by the other voters' 74.72 votes. This is not proportional representation; for over 11 per cent. of the voters are, owing to the use of Droop's quota, totally unrepresented. For the same reason—the use of Droop's quota in allotting the votes, two men very little preferred by the voters, H. and L., have secured election. If we use Droop's quota to allot the votes, we never can be sure that we get the men most preferred by the voters.

Explanation of the Senate Rules Table.

With Droop's smaller quota, 9.34, four members get primary surpluses—that is, surpluses on first-choice votes. These have to be distributed consecutively in Columns IV, V, VI, VII, before the votes for any unsuccessful candidate. Each of the four surpluses is worth .66 of a vote. Their distribution to the next available candidate on each ballot paper, as fractional surplus values calculated to two places of decimals, is given, with each grade of vote marked on the line, on 23 lines under five columns—IV-VII and X and XI.

All these four primary surpluses are due to the use of Droop's quota. Had Hare's quota been used, every one of the 40 votes the four candidates get would have been counted as a whole first-choice vote; whilst under Senate rules every one of these 40 votes has .066, or .07, used as a lower-choice vote, of grades ranging from the second to the eighth, as shown in 28 entries on this result sheet, contrary to the first-expressed wish of each of the 40 voters, which first wish would be carried out if the rules fixed Hare's quota, not Droop's. This is contrary to the principle enunciated by both Pim and Humphreys—that all first choices must be given effect to firstly, before second or lower choices should be used. It is also contrary to the other principle—that of the equality of all choices, whole or fractional, of the same grade; for, on every one of these 40 first-choice votes, .066 of the vote is not treated like the remaining .934 of the vote. It is used not as a first-choice vote, but as a lower-choice vote. Both these principles are violated in each one of these 28 entries.

Further, we have seen this election can be finished in exact conformity with the voters' directions on sixth-choice votes. Nine of these entries are those of choices lower than the sixth; and therefore should not be used as they here are, securing the election of L and H. So much as to the wholly unnecessary and improper distribution of the 2.64 primary surpluses which the use of Droop's quota necessitates: in every one of the 28 entries a lower choice is used, down to seventh and tenth choices, in place of the first choice made effective in the case of every one of the 40 votes when Hare's quota is used. Having seen that in every case of primary surplus distribution in this election Droop's quota necessitates that instead of the voter's first choice being made wholly effective for representation,

a lower grade of choice, running from the second to the eighth, has been used.

Let us examine what happens with the transfer of unsuccessful candidates' whole votes under Senate Rules.

There are six such cases, and in every one of them a lower choice is used than is used with Hare's quota under the suggested rules. We shall take these six cases one by one.

*Vote 10, BACMJIDHEL, used under the suggested rules as a first choice for B, here helps to elect A second choice and L tenth choice, and owing to the use of Droop's quota, the third, fourth, and fifth choices for C, M, J, respectively, cannot be used. The tenth choice for L should not be used because other voters' choices higher than the seventh can become effective in this election in electing another candidate.

*Vote 21, DIMACBHJEL, used under suggested rules as a sixth-choice vote for B, is here improperly used as a seventh-choice vote for H. The use of Droop's quota makes the third and fifth choices for M and C, respectively, useless.

*Vote 23, EIAJMCDBHL, used under the suggested rules to elect A, goes here through D as a ninth-choice vote to elect H improperly, for other voters' choices higher than the seventh can finish this election by electing another candidate. Here, too, Droop's quota makes the third, fourth, fifth, and sixth choices for A, J, M, C, respectively, useless, for it elects them on 9.34 votes, while with Hare's quota this vote might have helped them get 10.5 votes.

*Vote 47, IDEBJMACHL, used under suggested rules as a fourth-choice vote for B, here goes as a tenth-choice vote to elect L. On it choices for J, M, A, C are rendered useless by the use of Droop's quota.

*Vote 20, DCHIBEJALK is here used as a third-choice vote for H, while under suggested rules it goes as a second-choice vote to elect C. Here, too, Droop's quota makes the choices for J-A useless.

*Lastly, Vote 22, EBLHMJICDA, used as a second-choice vote for B, goes here as a third-choice vote for L, and Droop's quota makes the fifth, sixth, eighth, and tenth choices useless. In all six cases whole votes, as in all the 40 cases of surplus transfers, have lower choices used for other candidates, while higher choices on each ballot paper could have elected other members.

21. *Demonstrated Results from using Droop's Quota in Allotting the Votes.*—I have thus shown that on every single ballot paper transferred in this election under Senate rules a lower choice is counted than is counted under the suggested rules. I have shown, too, that H and L are elected by seventh, eighth, ninth, and tenth choice votes, which need not have been looked at, and should not have been used, as other voters' sixth choice votes conclude the election, electing B and F in place of H and L.

who are shown by the table of choices to be two candidates very little preferred by all the voters.

Further, on every surplus ballot paper transferred at this election under Senate rules, Droop's quota causes the counting of lower choices than are counted when Hare's quota is employed, and in the six whole votes that are transferred makes choices expressed for the four most popular candidates useless, owing to their election on 9.34 votes in place of the 10.5 they can receive when Hare's quota is used. They thus necessitate the counting of lower choices on these ballot papers, and it is on these lower choices that H and L secure election. At the 8th and 9th counts these two votes 23 and 44 would go to B, in place of going, as they do here at the 10th choice, to L.

Beside all this, with Droop's quota, in this election 9.28 votes are necessarily non-effective, while under the suggested rules every one of the 79 votes, which are left over after the five plumpers for L are subtracted from the 84 votes, take part in electing the eight members, and only a value of .95 on two of them is not actually used in their election.

Here, as in the Hospital Board Election, the use of Droop's quota under Senate rules gives four defects:—

(*a*) Four primary surpluses in place of none.
(*b*) The value of 2.64 first-choice votes on 40 ballot papers, distributed on lower choices from the second to the eighth, in place of being used as first-choice votes.
(*c*) On each of these 40 votes received by G, J, M, K, a smaller share, amounting to in all 2.64 votes, is retained as first-choice votes for these members.
(*d*) Lower choice votes than sixth-choice votes on these and the six whole votes of the unsuccessful candidates were counted, and elected two members—H and L, who were two members very little preferred by the voters.

These defects are in addition to the others common to every election under Senate rules; and all these defects can be avoided by the application of Mr. Pim's rule 5, and the use of Hare's quota, with Gregory's system of surplus distribution, to select the members most preferred by the voters.

By the use of Droop's quota we find the smallest number of votes by which each of several members can secure election, and by this quota we count the really effective votes in any election, effective, that is, in electing the members.

But in elections by the transferable vote, our object is to find the largest possible number of votes which each member can obtain. We want to find the largest possible number of votes that can be allotted to each member, for it is only by so doing that we can find out the *n* members most preferred by all the voters, and give every voter his equal proportional share of representation.

In elections with the transferable vote we have different grades of votes—the first grade of first-choice votes expressing

the highest grade of preference, the second grade of second-choice votes expressing the next highest grade of preference, and so on downwards; and to find the voters most preferred, we must count as many as possible of these first-choice votes and other high grades. Our first object, before counting the votes, is to allot to each candidate all the votes to which he has the best right. This must be done to enable us to find out the candidates most preferred. If we attempt to allot these votes by Droop's quota, we of necessity fail to carry out the fundamental principle of "giving effect to the first and higher preferences before making use of lower preferences."

We are compelled, as we have seen in these two elections, to make use of lower choices than if we use Hare's quota, and in this way we fail to carry out the voters' directions, as they have marked them.

In both of the elections we have examined, Droop's quota makes use on our transfer sheet of grades of votes lower than those at which the election can be finished; and in the last case two of the members are elected by grades of votes from the seventh to the tenth, while the election can be finished on the examination and use of sixth-grade votes.

In that election, under Senate rules every ballot paper is partially or wholly transferred on lower grades of vote under the Senate rules than under the suggested rules, owing to the use of Droop's quota. In the last Cape Hospital Board Election every entry but one on the result sheet of the transferred votes includes the value of third or fourth choice votes when the Senate rules are used, while the suggested rules show it can be finished by the transfer of the value of 95 second-choice votes on the ballot-papers which are available after the first count. Hare's quota is absolutely necessary for the proper allotment of the votes to the candidates who have the best right to them, and to carry out the plan Andrae, Hare, and J. Stuart Mill advocated. In no other way can Proportional Representation be secured.

In the other election by 84 voters, owing to the use of Droop's quota, 40 surplus votes are transferred on choices lower than the first, which is the only one counted if Hare's quota is used. At this election, also, all six whole votes are transferred to candidates marked lower on each of the six ballot papers than are members whose election they help to secure when Hare's quota is used.

Note (October, 1916).—The rules adopted by the Cape Proportional Representation Society last month, which provide for the use of Hare's quota, very much strengthen the case against the use of the Senate Rules and Droop's quota, as they finish this election by the transfer of eight second-choice votes. It is given below:—

		G	J	M	K	A	C	B	F	L	H	E	D	I	Exd.	Total
		10	10	10	10	9	9	1	7	7	6	2	2	1		84
L	7							2							5	7
H	6		2	1		1		2								6
D	2						1							1		
E	2							1						1		
I	1												1			
	—												Exhausted 5			
	18	10	10·5	10·5	10	10	10	6	7				Effective 74			84
			1·5	·5					Non-effective				1	2	5	5

Effective votes 74, outstanding votes 5, exhausted votes 5. B, lowest member, has 6 votes. These 6 non-effective votes 44, H J C A M D I E B; 45, H J M C A B; 46, H M C J A B; three surplus votes of the value of .75, .75, .5; and three whole votes, 23 E I A J M C D B; 21, D I M A C B; 47, I D E B, by the fourth choices are all concentrated on the 8 members, giving surpluses of 1.5 to M, 1.5 to J, and 1 to A and 1 vote to B; all these votes go to B, giving him 4 more votes, and securing complete proportional representation as far as the marking of the choices on the 79 ballot-papers will allow. J, M, A, C each get 10.5 = 42; B, G, K each get 10 = 30; and F has 7;—or 79 in all. This with L's 5 plumpers = 84, giving as on 2nd choices complete Proportional Representation as far as the voters' marking of their choices will permit.

SOME OBSERVATIONS ON THE LIFE HISTORY OF THE PEPPER TREE CATERPILLAR, *BOMBYCOMORPHA PALLIDA* DIST.

By David Gunn.

(*Printed as Bulletin No.* 5, 1916, *of the Division of Entomology, Department of Agriculture, Union of South Africa.*)

NEW TOPOGRAPHICAL METHODS AND INSTRUMENTS.

By W. C. van der Sterr.

(*Printed in "Journal of the Institute of Land Surveyors of the Transvaal." Vol.* 3, *No.* 8, *December,* 1915. *pp.* 346-368.)

ATOMS, OLD AND NEW.

By Prof. D. F. du Toit Malherbe, M.A., Ph.D.

(*Not printed.*)

THE INTENSITY OF RAINFALL IN THE TRANSVAAL.

By G. W. Cox, F.R.Met.S.

(With six text figures.)

What would seem to have been the first observation on intensity of rainfall in the Transvaal, was made at Doornfontein, Johannesburg, on December 18th, 1896. At Joubert Park, in the immediate vicinity, similar records date from a few days later; but the effort to obtain such data did not extend beyond these two stations until the inception of the Transvaal Meteorolgical Service in 1903.

SEASONAL DISTRIBUTION OF RAINFALL AND FREQUENCY OF HEAVY FALLS.

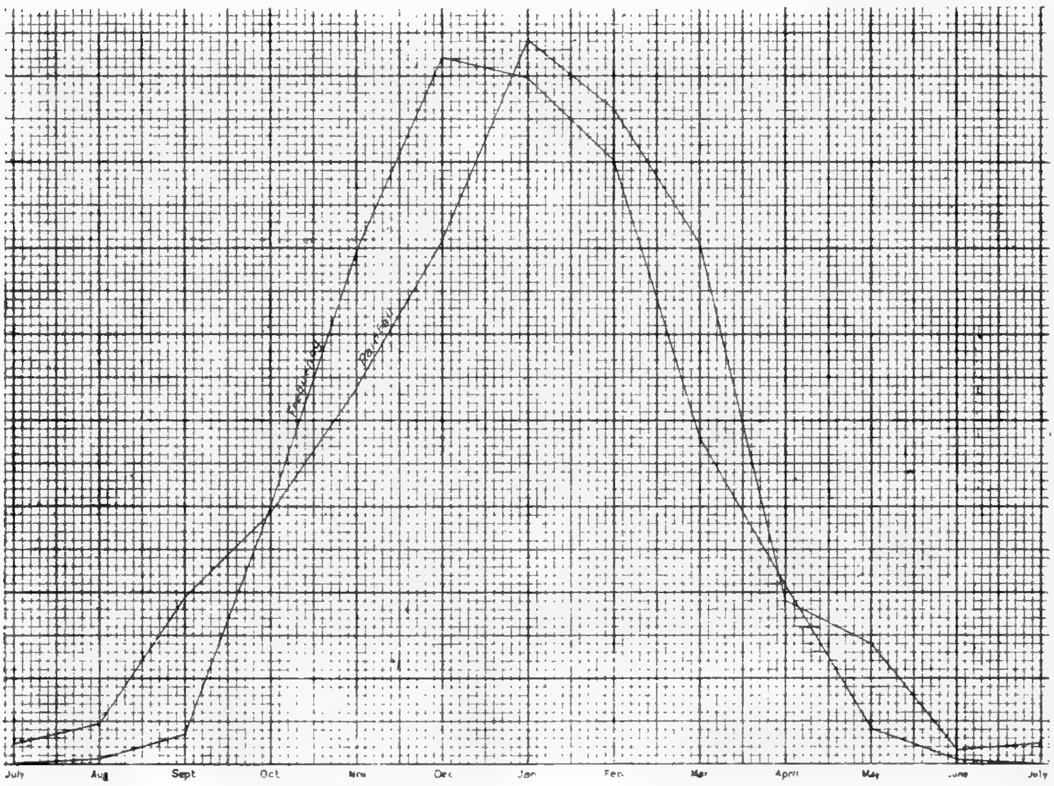


FIG. 1.

The period covered by the observations is therefore comparatively short; yet the data now amount to some thousands in number, and are fairly representative of all parts of the country, excepting the unhealthy regions of the Low Veld. Rainfall of no extraordinary intensity is, however, largely represented, and it is necessary to eliminate observations of this nature as far as possible. To effect this elimination, a somewhat arbitrary method is adopted, falls being rejected as unworthy of special notice when below:—

0.25	inches in	5	minutes.
0.30	„	10	„

0.35	inches in	15	minutes.
0.40	,,	20	,,
0.45	,,	25	,,
0.50	,,	30	,,
0.55	,,	35	,,
0.60	,,	40	,,
0.65	,,	45	,,
0.70	,,	50	,,
0.75	,,	60	,,
0.80	,,	80	,,
0.90	,,	100	,,
1.00	,,	120	,,
1.26	,,	180	,,
1.44	,,	240	,,

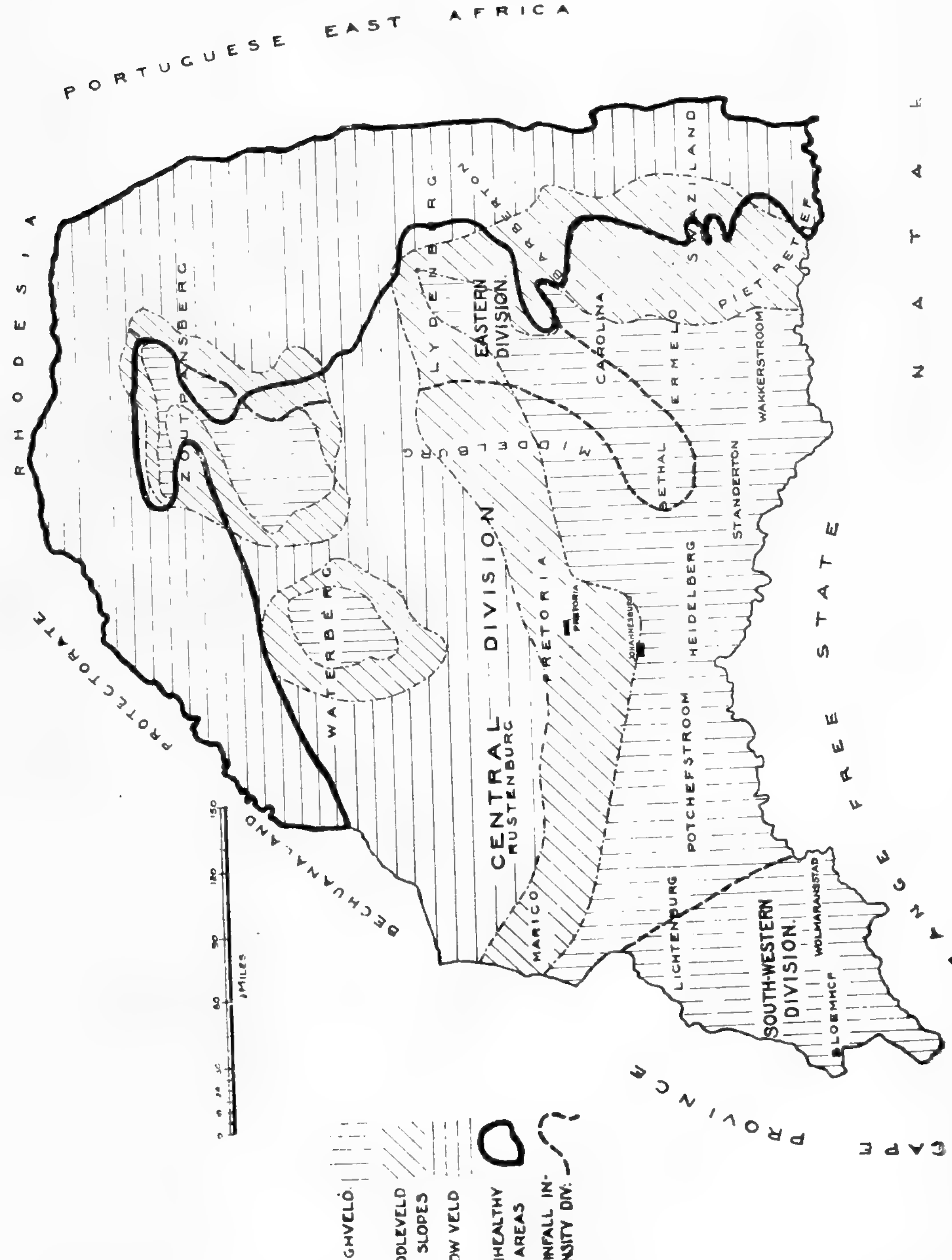


FIG. 2.

After removal of irrelevant observations, 1,557 records remain,, with a distribution over the year as follows:—

Jan.	Feb.	Mar.	April.	May.	June.	
319	281	151	83	17	2	
July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
—	3	14	119	239	329	1,557

The curves of Fig. 1 represent this frequency distribution, compared with the monthly rainfall. The former increases more rapidly than the latter in the early part of the rainy season, reaching the maximum a month earlier; a more rapid decrease in March is also evident. A greater probability of heavy downpours during thunderstorms suggests periodicity in the different types of pressure distribution over the country as an explanation of these peculiarities.

The most remarkable rainfall yet recorded in the Transvaal occurred at Wolhuter Kop on February 18th, 1915, when 4.19 inches fell in 30 minutes. Although exceptional, this storm is not without precedent outside the Transvaal. At Curtea-de-Arges, Roumania, on July 7th, 1889, 8.05 inches were recorded in 20 minutes; whilst the United States have on record a fall of 8.80 inches in one hour at Palmetto, Nevada, during August, 1890, and another of about 11.50 inches in about 80 minutes at Campo, California, during August, 1891. There is some uncertainty about this last fall, the raingauge having been washed away.

These intense isolated rains, however, seem to be confined to certain mountainous regions, and their significance is restricted. For the comparison of intensities experienced in different countries, or different areas of the same country, a number of falls scattered over an extended area furnish a better standard, especially if they disclose a more or less constant relation between time of duration and the amount of precipitation. In that case, by taking only the heaviest falls recorded during various intervals of time, some idea may be obtained of the probable maximum amount of rainfall to be expected in that area during a stated period.

When seeking such a relation in the Transvaal, the decrease in rainfall from east to west of the Province, concomitant with increase of distance from the source of moisture supply and alterations in the physical configuration of the country, suggests a variation of intensities with geographical position. As this evidently exists it is convenient to consider the data under three divisions as shown in the map (Fig. 2), reproduced by kind permission of Mr. Tudor G. Trevor, A.R.S.M., F.G.S. The eastern slopes of the Main and Zoutpansberg plateaux and part of the north-eastern High Veld fall under the Eastern Division; the South-Western districts under the South-Western Division, and the remainder of the country under the Central. For the unhealthy parts of the Low Veld only meagre information is

SOUTH-WESTERN DIVISION.

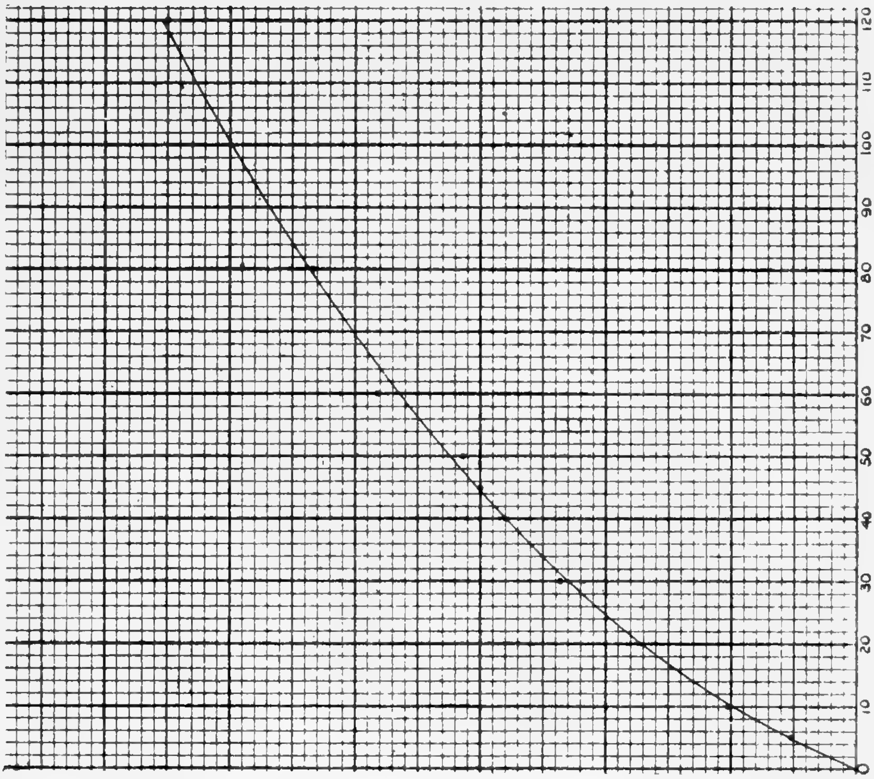


FIG. 4.

Amount Inches 3.00 .75 .50 .25 2.00 .75 .50 .25 1.00 .75 .50 .25 Minutes

CENTRAL DIVISION.

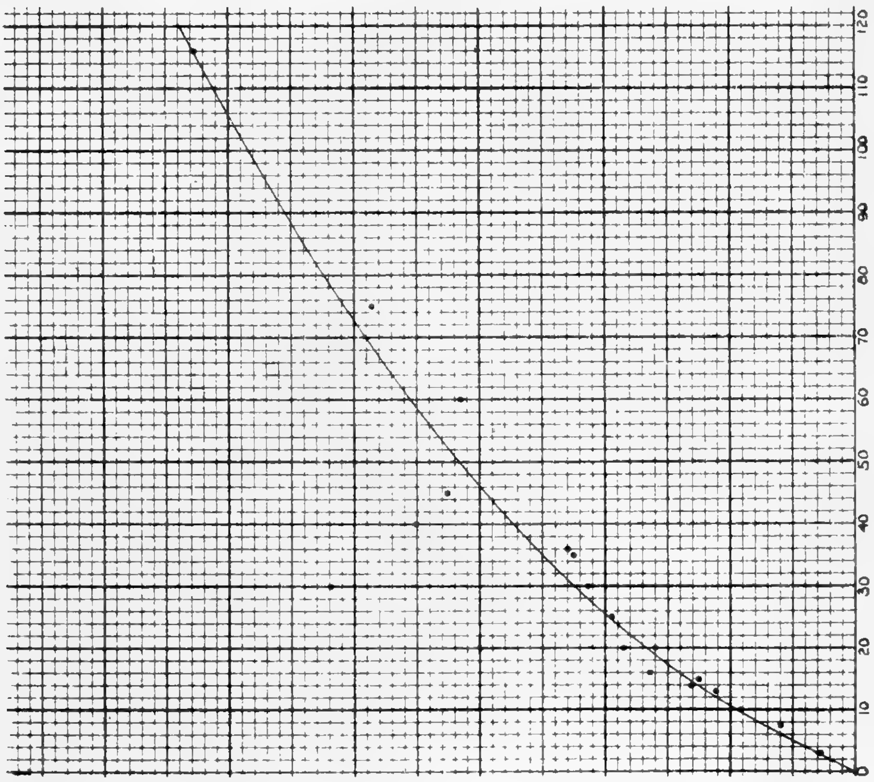


FIG. 3.

available, and they are therefore excluded. When so divided the greatest falls of not more than two hours' duration show an increase of amount with respect to time which may approximately be connected by an expression of the form:—

$$h = e^{a\left(\log_e t\right)^n}.$$

The most probable values of the constants having been calculated from the data, the following equations are obtained:—

$$h = e^{3\cdot843\left(\log_e t\right)^{\cdot318}}. \quad \ldots \quad \ldots \text{ Eastern Division.}$$

$$= e^{3\cdot178\left(\log_e t\right)^{\cdot436}}. \quad \ldots \quad \ldots \text{ Central Division.}$$

$$= e^{2\cdot586\left(\log_e t\right)^{\cdot496}}. \quad \ldots \quad \ldots \text{ South-Western Division.}$$

EASTERN DIVISION.

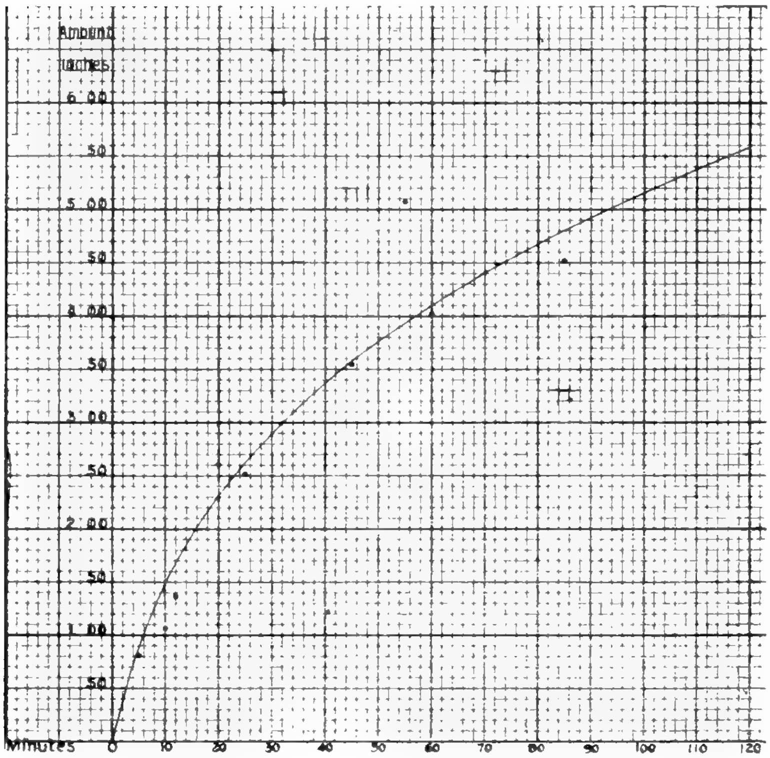


FIG. 5.

where h is amount in hundredths of an inch and t time of duration in minutes. These are the equations to the curves of Figs. 3-5, some values of which are here given against actual amounts recorded:—

Time	Value of Curve.	Actual Amount Recorded.	District.	Station.	Lat.	Long.
Minutes.	Inches.	Inches.	Eastern Division.		S.	E.
5	0.87	0.81	Bethal ..	Watershed ..	26°28′	29°38′
10	1.50	1 07	do. ..	do. ..		
12	1.70	1.37	Zoutpansberg ..	Downs	24.09	30.11
20	2.32	2.61	Piet Retief ..	Cascades ..	26.47	30.44
25	2.63	2.52	Lydenburg ..	Schoongezicht ..	25.34	29.57
45	3.58	3.55	Barberton ..	Castle Kop ..	25.40	30.56
55	3.94	5.07	Swaziland ..	Bailey's Creek ..	26.20	31.06
60	4.10	4.02	Piet Retief ..	Cascades ..	26.47	30.44
85	4.81	4.52	Swaziland ..	Bailey's Creek ..	26.20	31.06
			Central Division.			
3	0.30	0.28	Witwatersrand ..	Oakdene ..	26.15	28.03
7½	0.75	0.60	Pretoria ..	Pretoria ..	25.44	28 13
10	0.97	0.92	Marico ..	Welbedacht ..	25.29	25.59
13	1.20	1.12	Potchefstroom ..	Mooi River Estates	26.11	27.09
14	1.28	1.31	do. ..	Haaskraal ..	26.50	27.03
15	1.35	1.25	Ermelo ..	Clifton	26.28	30.28
16	1.42	1.64	Pretoria ..	Pretoria (Irrigation Store) ..	25.45	28.11
20	1.68	1.85	Wakkerstroom ..	Glenmore ..	27.18	30.00
		1.60	Witwatersrand ..	Rose Deep ..	26.12	28 11
25	1.98	1.95	do. ..	Germiston ..	26.14	28.09
30	2.25	2.13	Pretoria ..	Pretoria (Municipal Works) ..	25.45	28.11
		4.19	Rustenberg ..	Wolhuters Kop ..	25.43	27.42
35	2 50	2.25	Pretoria ..	Fountains ..	25 47	28 12
36	2.55	2.30	Pretoria ..	Pretoria ..	25.44	28.13
40	2.74	3.50	Witwatersrand ..	Vierfontein ..	26.16	28.01
45	2.96	3.26	Waterberg ..	Grootvlei ..	24.32	28.42
		2.95	Rustenburg ..	Wolhuters Kop ..	25.43	27.42
60	3.55	3.15	Carolina ..	Leeuwpoort ..	26.01	30.14
75	4.08	3.85	Witwatersrand ..	Johannesburg (Joubert Park) ..	26.11	28.03
116	5.27	5.27	Pretoria ..	Lyttleton Junction	25.48	28.12
			South-western Division.			
5	0.26	0.26	Bloemhof ..	Christiana ..	27.55	25.10
10	0.50	0.51	do. ..	do. ..		
30	1.15	1.18	do. ..	De Hoop ..	27.47	25.11
45	1.48	1.50	Lichtenburg ..	Doornbult ..	26.48	25.38
50	1.62	1.57	Wolmaransstad ..	Wolmaransstad ..	27.12	25.59
60	1.82	1.91	Lichtenburg ..	Barberspan ..	26.35	25.35
80	2.18	2.17	Bloemhof ..	Christiana ..	27.55	25.10
120	2.77	2.75	Lichtenburg ..	Turflaagte ..	26 19	26.07

Two rains in the Central Division do not conform to the general trend of the curve; the Wolhuter Kop rainfall mentioned above, and another of 3.50 inches in 40 minutes, which occurred at Vierfontein on January 17th, 1915. Wolhuter Kop lies at the foot and to the north of the Magaliesberg, and Vierfontein to the north of the Klipriversberg range.

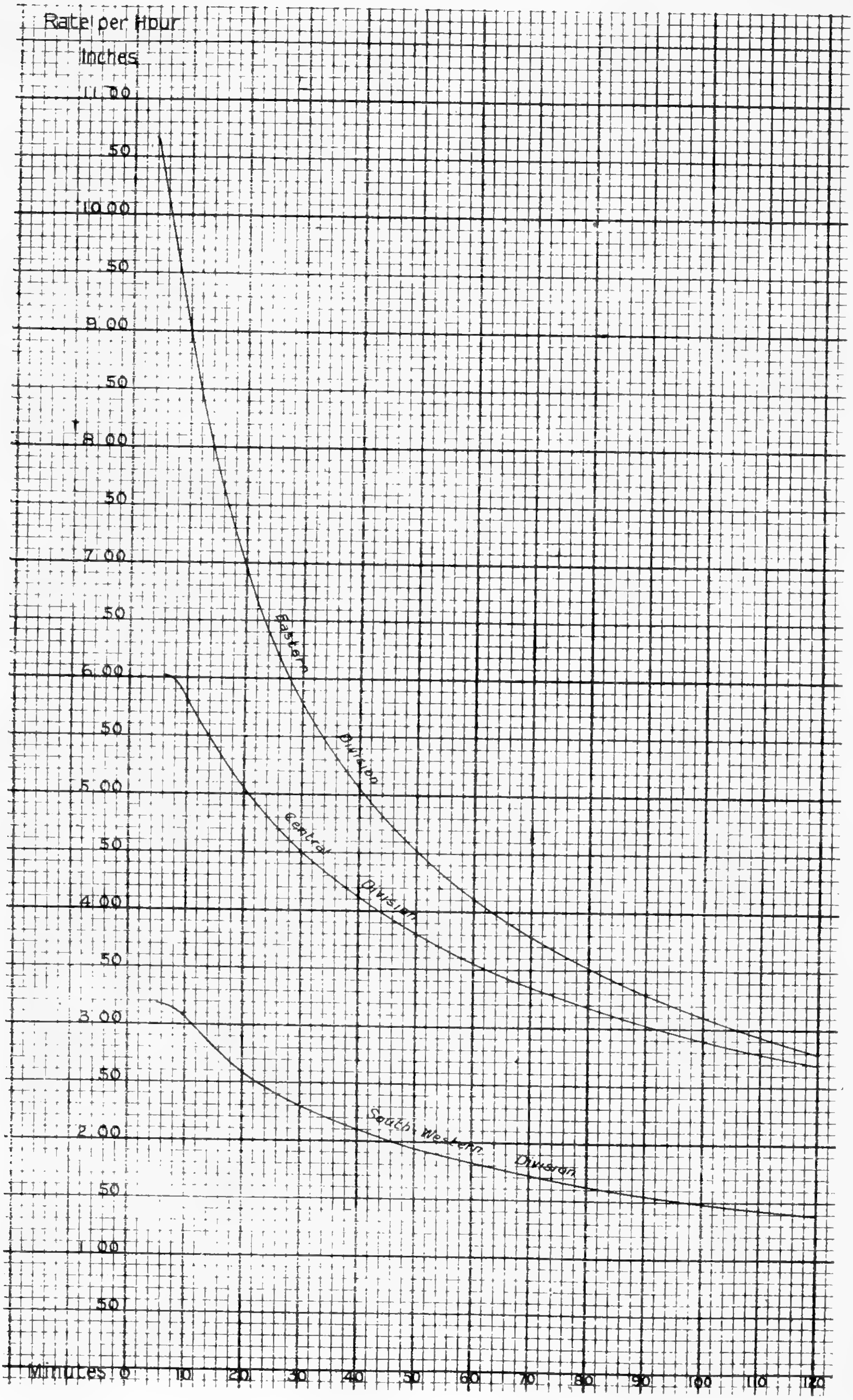

Rate per Hour
Inches
11.00
50
10.00
50
9.00
50
8.00
50
7.00
50
6.00
50
5.00
50
4.00
50
3.00
50
2.00
50
1.00
50
Minutes 0
10
20
30
40
50
60
70
80
90
100
110
120
Eastern Division
Central Division
South Western Division

FIG. 6.

In very few countries has much attention been devoted to intensity of rainfall during short periods, and the consequent paucity of information precludes comprehensive comparison between the Transvaal and other areas of the world's surface. In the British Isles, however, where data has been assiduously collected, only one fall which would lie above the curve for the Eastern Division has been recorded during 46 years.* More especially over the longer periods, where errors of observation are relatively small, the British records fall well below the Transvaal. This single comparison at least serves to exhibit more clearly the great intensities experienced in parts of this country, where both physical configuration and the character of the rainfall combine to favour heavy downpours. Thunderstorms are the principal agents of precipitation, and these storms, usually travelling from south-west to north-east, have a motion opposed to the prevailing surface winds. They are thus fed by an absolute movement of the air towards them, not by a relative movement such as would be associated with convectional thunderstorms, travelling in the same direction as the surface currents.

Incidentally it may be noticed that the December isobars at 4,000 metres, as computed by Teisserenc de Bort, would necessitate a circulation of the atmosphere at the height closely agreeing with the direction followed by thunderstorms.† Whether the accompanying clouds travel at that height cannot be definitely stated at present, but it may be remarked that a series of measurements made in connection with a storm approaching Pretoria gave 4,465 metres above sea-level as the mean height of their apices.

With few exceptions, the rainfall data dealt with here are the results of observation with ordinary 5in. gauges, exposed with their rims 4ft. above ground level. Unfortunately, only a few of the automatic instruments used in South Africa produce records adapted to the extraction of short period intensities.

ON THE DESIRABILITY OF FOUNDING A SOUTH AFRICAN ENTOMOLOGICAL SOCIETY.

By Antonius Johannes Theodorus Janse, F.E.S.

(*Not printed.*)

SOME ASPECTS OF MODERN NAVAL DEVELOPMENT.

By Harold Cecil Kenway.

(*Not printed.*)

* British Rainfall, (1914).

† Dr. J. R. Sutton states they approach Kimberley from north-west or west ("An Introduction to the study of South African Rainfall." *S.A. Phil. Soc.*, **15**, 25).

PRACTICAL EDUCATION.

By William James Horne, A.M.I.E.E.

I have chosen a popular title for the remarks I am about to trouble you with, because I wish to interest that greater number of parents whose children will become skilled artisans, working agriculturists or qualified clerical employés. Intended to catch the eye, this title does not define sufficiently clearly the scope of my observations; briefly, I wish to discuss the possibilities and requirements of vocational education. At this distance from the centre of things,* my ideas may be but crudely expressed, and my remembrance of the work of others, here and elsewhere, somewhat sketchy. If I am able to say anything in a manner sufficiently new to interest educationists, I shall be doubly rewarded.

When we regard a system of national education from outside, it is important to consider first the minimum attainment that it should aim at; secondly, the maximum achievement that ought to be its ideal. There may be no limit to the ideal; but it seems to me that the lowest minimum we can allow is that the girls should become fit for motherhood and be mentally and technically fitted to manage a household, and that the boys should become fit for fatherhood and be mentally and techincally fit to earn a living wage in some department of labour. That is, each sex qualified to carry on the daily round in its own sphere, and maintaining a cheerful temper in doing so. Now nothing is more certain that the child whose education is stopped at the age of thirteen, fourteen or fifteen, cannot have received this minimum. That parent who says to the young boy or girl of fifteen: "You have learnt enough foolishness at school, it is time you went to work," does an incalculable injury to the child and to its future value to the country. That parent who asks: "Why don't they teach children something useful at school?" —meaning thereby a course of instruction that will create a demand for the child in the labour market, commercial or otherwise, does not understand the functions and necessary limitations of the ordinary school. The worst of talking about education is that so many still think of it as something put into the mind instead of as something drawn out of it; that, in fact, the school is a kind of glorified warehouse dealing in intangible materials of which the pupils receive an assortment in quarterly instalments, which they will be able to retail at considerable profit, at some future fixed date in the examination market, even if the goods delivered by the pupil are considerably reduced in value by the process. This attitude of mind, of course, is not conducive to education, and can only lead to the very state that parents and employers are ever ready to complain of, namely, scrappy knowledge on the part of the scholar. South Africa

* This paper was written in German South-West Africa.

has been described as examination-ridden; I regretfully agree. It is not the fault of the examining bodies! neither is it the fault of the teachers. The people get the Government they deserve, even in educational matters; the first step to a cure must be taken by the parents. As long as school committees foster the examination craze by gauging the educational abilities of the school staff on the number of children "put through" any given examination, as long as parents measure the want of educational attainment in their child by its failure at a certain examination—so long will the present unsatisfactory state continue. The security of tenure and further advancement of the teacher depends, in too many schools, upon the number of "passes" that can be shown; remove this incubus, and the teachers will heave a sigh of relief and pass from the cramming mill to his proper sphere, that of education.

I would remove the vulgar—in the sense of popular—view of education, and substitute for it the definition given by an eminent American commission of education: "Real education is the vital interaction between a mind and its world." The child's own world is small, and he probably re-acts intelligently under its stimulus; the world outside the child is large, and under its influence he re-acts more or less incoherently, more or less intelligently. The child, as it were, is under the fire of an education battery of some four guns, each using very different ammunition, with the added disadvantage that the battery as a whole is not under the control and direction of a single commander, but that each gun is firing when, how, and where its individual gun-captain may wish. These agencies for education that I have likened to guns are: (1) home, (2) neighbours, (3) school, and (4) church. This distribution of educative power is not in fixed divisions, set once and for all by previous tradition or practice. Together these agencies carry out the total work of education with the economy and such efficiency as comes through a division of labour; a new sociological order and a more complex environment have weakened the powers of some of them, however. Thus the town homes of the artisan class have not that parental authority and control over children exercised by the family life of the farmers; theological doctrines grip fewer numbers now than a century ago; apprentices learn less of the intricacies of their trades in modern factories than their forerunners did when these trades were lodged in the employers' household; the junior employé in a mercantile house learns less of the ramifications of business methods now than his type did fifty years ago, when identification with "a house" meant, practically, identification for life. Under the flux of changing conditions, those influences hitherto brought to bear by the other agencies are, as they become weakened and inoperative, demanded from the school. As the moral training of the church and family life become insufficient, we find moral education included in the school curriculum. As children, owing to the restrictions

imposed by city life and the provision of cheap amusement, cease to develop robust physical activities in the open air, the school is called upon to provide systematic physical training. As the industrial workshop and the commercial house become more scientific and specialised, and as the present system of apprenticeship fails to give the grounding and training necessary to the efficient and satisfied worker, so the obligation to make good the want is placed upon the educational system of the nation. This demand for vocational education is a rational one, considered in the light of modern industrial and commercial conditions; it has been felt and met by other countries, resulting in a quicker output and a better service, both without deterioration in quality.

What appears to be irrational, is the popular demand that vocational education should be provided in the ordinary or primary school. It has been pointed out that the primary school can give a general training for life as a whole, but that it cannot do so for the *business side* of life, except in a very limited and restricted sense.* Even if the primary school teacher was a master in some craft, or an expert in some branch of business, he could not find the time, either on his own part, or on the part of his pupils, to impart his vocational knowledge. It is essential that the child's mind should re-act intelligently to external mental stimuli, so that the child may be fit as a member of the general community. He is there to see that that vital interaction between the mind and its world, which is education, takes place; and he does so by gradually widening the child's world, here softening one stimulus, there strenthening another, leading him to increase his perceptive powers. To effect this he has to teach his pupils certain instrumental subjects, namely, reading, writing, arithmetic and drawing. Super-imposed upon these, for the reasons already given, Biblical and moral knowledge and personal hygiene, with physical exercises for the body. Together with these, some cultural subjects are necessary, such as history, with geography, singing, a little general science, some manual training, or hand work in wood or in metal, parallelled for girls by lessons in cookery (in order to balance the effect of the other necessarily bookish subjects), and possibly, later on, an introduction to literature. Add to it all the necessity for dual language provisions, and it will be clear that both pupils and teachers, in the ordinary or primary schools, are very busy persons indeed. But, it may be urged, it is possible to give these subjects a more vocational basis than is already done during the ordinary primary school years. I do not think so. To take reading for example; this subject is an "instrument" for inculcating the proper use of language; for this purpose a large amount of reading aloud must be done; the subject-matter must be within the grasp of the pupils, and just sufficiently beyond their experience to be

* Sir Percy Fitzpatrick, in his Preface: "The Trades School in the Transvaal."

interesting; the proper use of books as treatises to be consulted for information, is not yet; pupils "read for the story" well into their teens, because the spirit of romance is strong in youth; it would be a grievous pity to kill endeavour by stifling instead of directing this romantic spirit to useful after-effort, by substituting the elementary technical manual or commercial text-book for the civic reader. To spelling, on the other hand, reformers on the look-out for economy in school-time, might well turn their attention; memory work in this connection is nearly as wasteful of time and grey matter as our systems of weights and measures. To spell correctly in English is exceedingly difficult, yet I am no Carnegieite who would alter standard forms; but perfection comes with practical use, and all that should be expected from pupils is the correct spelling of some two hundred words in common use with the intelligent handling of a pocket spelling guide, and not that they should be expert in all the words that can be found in a shilling dictionary. Scholars in primary schools have not now to suffer the astounding nomenclature, fantastic classifications and the distinctions with fine differences of formal grammar; their acquaintance with it is limited to that required for the recognition of and ability to formulate a sentence. With regard to arithmetic, I do not see how a greater accuracy can be attained by substituting practical calculations for pure arithmetic, by beginning early with concrete examples; I think the child's mind would be confused beyond hope. Much of the present arithmetic text should be scrapped; I have already referred to our systems of weights and measures—those effete descendants of a defunct guild mysticism—arithmetical subtleties such as problems, however simple, based upon "remainder theorems" should go, as also those which apparently assume that the pupils are going to earn their livelihood by buying money when it is cheap and selling it when it is dear. The time saved should be spent in drill with "the four rules." Fractions should be begun with denominators in tens only, and non-recurring decimals introduced immediately; further practice in the four rules should then be given with the decimal system with the gradual introduction of "approximations." The calculation of area should be followed by simple square root and of volume by cube root. Fractions with other denominators than ten and its powers would be the next step and, thereafter, problems including the use and sub-division of money. Everything else in arithmetic should be sacrificed in the primary school to accuracy and speed in this minimum equipment.

Parents and others are apt to make the mistake of thinking that the manual training instruction given as part of the ordinary or primary school course is intended as a training for what I have already called the business side of life; that the boy is being pre-trained as a wage-earner; that the school woodwork class is a kind of apprenticeship training in the trade of carpenter, and the metal-work instruction a kind of pre-training for that

of the steam-fitter. Nothing could be more erroneous. The aim of this kind of instruction is totally different to that of the trade workshop; its object is to get the hand and the eye working together, to correlate the mind and the body; it is another method of getting the child to think by letting him work at something he imagines to be definitely useful in solid materials. Instead of dealing with an abstract problem he deals with something concrete and real, something that he can turn over in his hand and in his mind instead of only in his mind. Thus manual training is more than a mere counter-irritant to class-room or desk studies, and is essential if the intelligence and adaptability of the pupil is to be as fully developed as is desirable by the primary school course. No one will deny that a wide range of contact with tools and with the materials to which these tools can be applied, either at the bench or on the lathe, gives a boy a certain amount of knowledge which would be useful to him if he were to enter a workshop as a learner; but the aim of the training must be realised by the parents—it is training in forethought and, as I have already said, in correlation between the hand and the eye, and it is not a training directed towards a future entry to some trade. It is more nearly comparable with that development which results from the spontaneous "experience-getting" when engaged in such highly-specialised games as football and cricket. Its method may be summarised in the phrase "nothing made which has not been drawn, and nothing drawn which cannot be made"; that is, of course, made by the pupil. Thus the course of instruction must deal with forms based upon the pupil's experience—his world—advancing in difficulty along a parallel road, with the classroom or desk subjects, and in such a way as will help his progress along either road. In other words, the manual training instruction is correlated with arithmetic, drawing and science, and even with history and geography. Thus the motive of manual training is not that of vocational instruction; its aim is not that form of vocational or trade efficiency which results from manual dexterity in some trade process—such, for example, as the ability to use a joiner's plane to make a piece of wood dead true on all four sides. There are other ways in which manual training is limited in its possibilities for vocational efficiency; beside the spirit of approach being educational in nature, and therefore partaking more of the amateur than of the tradesman style, and especially in those cases where the teacher has come under the arts and crafts movement, only a couple of hours each week can be allotted to it as a school subject; it is thus only an incident in a general education; again, the equipment and tuition in such a course lag very far behind the keen progress in either the wood or metal-working trades, because the use of modern labour-saving bench tools would lessen, seriously, the education to be derived from the instruction, even if the purchase of these tools were financially possible; and again, the teacher need not necessarily have been a tradesman.

Similarly for girls' subjects, sewing and cookery; the sewing class is purely domestic in its aim, it can make no preparation for vocational efficiency in "gentlemen's vests" or "ladies' coats," or even in dressmaking, where both stitch and method are different to those used in the home-life. Cookery, too, is tied by the "budget" of the home the girl may reasonably be expected to have; it can make the pupil a more economical consumer and raise her ideal regarding simple dishes and the treatment of food for the sick, but it cannot provide that vocational efficiency expected in the woman *chef*.

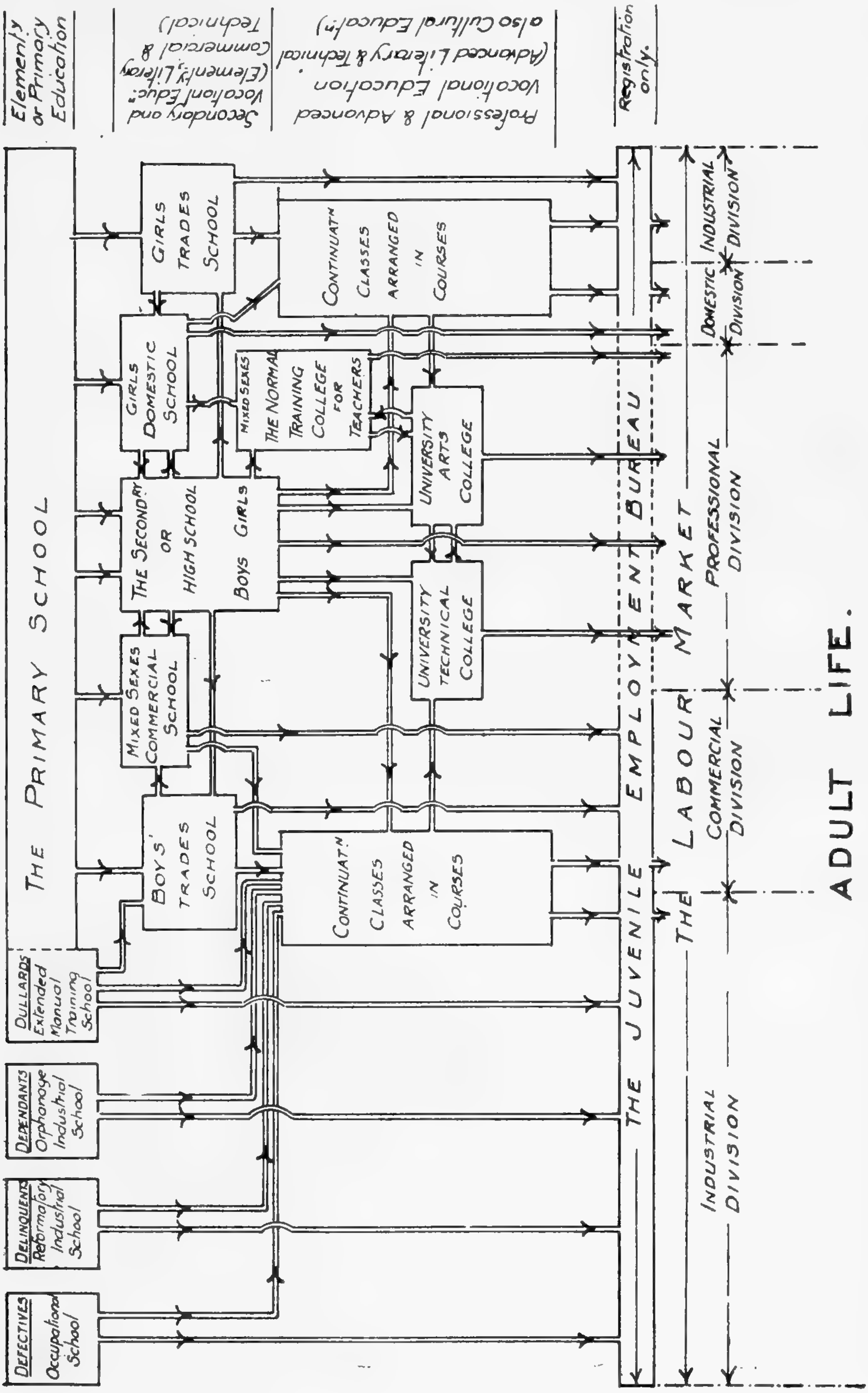
Thus, manual training (for either sex), and vocational education—in the sense of training for a particular vocation—have different aims, and are controlled by largely different purposes; each, however, contributes in some sort to the purposes of the other. Manual training, designed to give breadth to limited experience, to evoke interests and to stimulate a keen appreciation, cannot be identified with the intensive purpose and specialised nature of vocational education. Manual training is a part of general education, and as such must adhere closely to the contemporary life of the pupil; vocational education must be given under workshop conditions.

From the evidence of an increasingly complex social order, of the increasing competition between nations, and of the fact that a general education must necessarily concern itself with abstract studies illustrated only by concrete examples to maintain the interest and make the application clear—we are forced to the conclusion that vocational education must be given in a new system of schools specially devoted to this end. The evidence that the older agencies of vocational education—the home, the workshop, the free intercourse between son and father, as a means of participation in productive industry—are no longer sufficient, that modern apprenticeship, where it exists, no longer gives the comfortable assurance of a complete all-round trade training, could be multiplied. It is one of the certain social facts of the age we live in. There can be no doubt that the time has arrived when vocational education, as well as general education, must be provided for the greater mass in special institutions carefully organised for the purpose, deliberately selecting their courses and teaching staff, and shaping their methods to the end in view—the best type of worker and citizen. Many of the higher vocations have long been acquired under school conditions and often at public expense. The early universities had their schools of literature, law, medicine, and theology, each giving its own specialised vocational education for those seeking to enter one or other of the professions; to these have since been added professional schools for architects, chemists, and engineers. Of these, the training of teachers and of soldiers—both rank and file—is given almost, if not entirely, at the expense of the public exchequer. To train the leaders and not the ranks is suicidal, and the time is now come when it is necessary to

provide as careful and suitable a training for the industrial status as is considered necessary for the professional status. In fact, legislation for education in certain countries is already tending to make it compulsory upon every individual to attain some vocational education just as compulsion already exists to prevent illiteracy among the mass of the people. It is being recognised, gradually, that an educational system which ends with the end of primary school classes has not justified its existence, and that it cannot be justified until the minimum outfit for the business-side of life is the birthright of every child from the day it enters the ordinary school. Secondary education is the process that gives this outfit; secondary education that is in close association with the office, the workshop, the farm, and with domestic life. Higher elementary teaching in the ordinary or primary school is nearly useless for this purpose; that means that all education from at most the thirteenth year onward to at least the age of seventeen must be secondary in the sense just given. It is most desirable that this practical or vocational education of secondary type should be given in whole-time day-schools in view of the nature of the contemplated curriculum and on account of the pupils; somehow the life of children from fourteen to seventeen is an all-important period requiring the most watchful care, for upon the mental and bodily growth during these years depends the quality of the future life of the nation. Parents, therefore, should realise the necessity of keeping their children as long as possible at the kind of day school shown to be necessary even if this involves severe sacrifice on their own part. Circumstances, however, may render this impossible in some cases, and the makeshift of half-time or continuation schools be rendered necessary; but these must be held in the *day-time* and *not* at night—*i.e.*, not from 7 p.m. onwards—as at present. Night school work has been definitely proved so to drain the physical energy of youth as seriously to reduce the value of this national asset; it produces myopia, brain-fag, and even epilepsy in its victims; in fact, for the great number, it defeats its own object. If, therefore, it is our duty to consider future generations; if our imperialism is to take note of time as well as space—it is our duty as a nation to provide a minimum vocational education for the youth and to feed and clothe them, when that may be necessary, while they are undergoing instruction. All this means two things, money and future employment; vocational education is, of course, technical education, and technical education is, and always will be, expensive when its cost is compared with the few pitiful pence usually allocated to primary or ordinary education; it will be money well spent, and in any case other countries have attempted it and are succeeding. As for the over-stocking of certain callings with too many workers and the economic problems arising therefrom—these are matters for adjustment between the Boards governing the schools, the employers' associations and trade

unions. Unemployment is always largely local, and can be greatly mitigated by governmental juvenile employment bureaux in different districts.

I have illustrated my conception of the relation between one type of educational institution and another, and the relation of



the whole to life, in the annexed diagram. The child begins in the primary school, the path from which to the university and thence to professional life is through the secondary education given in the high school; flanking the high school, should be trades schools—one for each sex—commercial schools and domestic schools; opportunity for further study after leaving these vocational schools should be obtainable through continuation schools. Between each institution there should be the freest interchange to a flank—towards the higher institution for the capable, towards the more elementary one for those who have mistaken their ability or over-estimated their educational advancement.

Provision for the dull, the dependent, the delinquent, the defective—what have been called "the four D's"—must be made at the primary school stage; the necessary institution is the industrial school, partaking partly of the nature of the primary school and partly of the nature of the trades school; in country districts with a strong bias to the needs of the district—for boys, agriculture; for girls, dairying.

For convenience of treatment I have classified* the callings, into which the labour market practically divides itself, in four main divisions, namely:

(*a*) Industrial, or those containing—(1) manufacture involving a mechanic's training, and (2) agriculture, involving a farm training.

(*b*) Commercial, those ranging from shop-boy, cash-girl, etc., to those which rank as quasi professions.

(*c*) Professional, or those noted for the extensive educational training and elaborate development required before they can be practised.

(*d*) Domestic, including the commercial manufacture of cloth, bread, jam, pickles, etc., now produced in factories.

The most complex of these groupings is the industrial; it embraces all crafts, trades and manufacturing pursuits ranging from those requiring little or no training—*i.e.*, mainly requiring "labour" supplied in Europe by woman, children, and untrained men, and, in this country, probably, by the coloured races, but perhaps not altogether by them—to the higher trades requiring almost engineering ability. Of course, the degree of educational preparation, or preparedness, varies for each of the groups named; following the terminology adopted in the ordinary scholastic system, we may call that form of vocational education, which is adopted to the child of average ability under fifteen years of age, "elementary"; and that which is suitable for young persons from fifteen to eighteen "secondary"; while

* I have modified the classification adopted by the French, *viz.*: I, Professional; II, Commercial; III, Agricultural; IV, Household; V, Marine; VI, Industrial.

that intended for those beyond eighteen and holding corresponding attainments, may be called "higher." Professional education is usually classed as higher education; that is, students before admission are expected to have completed their secondary and, sometimes, their collegiate education. It is also true that under some circumstances the character of the elementary and especially of the secondary education given, is largely determined by the probable or even actual requirements of the profession to be studied for in the future by the pupil. For example, preparatory secondary education for the boy intending to adopt engineering as profession should be carefully considered. I have already had the honour of laying my views before you on this point on a previous occasion.* In the professional division the various University Colleges in the Union of South Africa make ample preparation for the higher technological, literary, and scholastic vocations; it is, however, to the lower technological levels or industrial divisions that the great majority of young people will gravitate, and it is to provide more extended opportunities in the primary-cum-secondary vocational field for future wage-earners that Trades Schools have been established in the Transvaal. In the industrial sub-division of agriculture we now have under school conditions, controlled by the Agricultural Department, the beginnings of higher grade agricultural education and that of secondary-grade well established—these terms being fixed partly by the age of the pupils and partly by the quality of the general educational attainment required in the pupils before admission to such Agricultural Colleges as Elsenburg, Cedara, Potchefstroom, etc. The primary grade education is still limited, however, as far as the Transvaal is concerned, to the manual work done in field and garden in all industrial schools and in some country schools; this might be taken up as a school subject† in certain of the larger country-town schools.

Provision in the Transvaal is made for the commercial and domestic divisions respectively by the Commercial Secondary School and School of Domestic Science, both in Johannesburg and Pretoria.

Vocational education has many difficulties inherent in it. That acquired through actual contact with its form in the home and in the workshop is strong in certain ways on the practical side; its weak points are—(1) the absence of theory, (2) its inability to provide an adequate understanding of the laws and principles underlying its practice, and (3) modern conditions—*e.g.*, cheapened production—narrow the practice given to some restricted branch of a trade. On the other hand, the class-room is particularly able in imparting the theory or abstract phases of a vocation, and is only partially adapted to combine these with

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* "The Relation of the High School to the University Technical College," Rept. S.A.A.A.S., Lourenço Marques (1913) 54-63.

† I have sketched a suitable scheme in the pamphlet "The Trades School in the Transvaal." Argus P. & P. Co., *Star* Office, Johanesburg.

actual vocational trade practice. We, therefore, arrive at the conclusion that a complete system of vocational education must provide training both in the practical and in the theoretic or text-book preparation; these theoretics may themselves be divided into two groups: those subjects which are essential in vocational education, and those which are not actually essential but are very desirable; the first group may be considered as containing technical subjects proper, and the second those of general vocational utility. See diagram on page 705.

In Great Britain, particularly, there has been established a wide range of technical schools in which the instruction given is almost wholly in theoretics, such workshops as there may be being merely for simple handicraft work in wood and metal for, at most, two hours a week. Institutions of this type have been so multiplied and copied that educationists and parents think not infrequently of vocational education solely in terms of the technical studies involved. Doubtless this notion has arisen largely because the higher levels of all technological callings require so much book and class-room study as to make it appear that abstract study is the essential factor. This, of course, is not actually so; such courses are always accompanied by very long and heavy courses of practical work in laboratories. Abstract studies, in fact, when divorced from concrete practice fail to produce the efficiency necessary. What is true in the training of the future leaders is more than true in the training of the future workers. Certain abstract studies are necessary, but they must accompany a considerable amount of actual productive work. I have already indicated why manual training cannot be considered as satisfying the needs of vocational education; with that I include those modified forms of practical work given in some schools as suitable for commercial employment, and in others as suitable for domestic life. The reasons lie in the want of correlation with the necessary technical subjects and in their remoteness from the practice adopted in actual production. It is, moreover, a matter of common experience now that technical subjects, such as mathematics, science, drawing as an art, and so on, produce the best results only when they are acquired in conjunction with the practical processes calling for their acquaintance. It is also known that the study of such subjects, in close relation with the productive processes referred to, helps to expand rapidly the capacity of the worker. It is, therefore, clear that when, in the opinion of the parents, the time has arrived for the child to consider what he (or she) is "going to be"—it is necessary to provide contact with reality not only as regards what may be termed the external characteristics of the vocation chosen, possibly provisionally chosen, but also as regards the amount of study necessary and education required, the social circumstances or status attaching to it, the market value it will give him as an employé, and so on. He (or she) needs to see different trades in actual operation;

THE LABOUR MARKET.		VOCATIONAL EDUCATION.		
Division.	Vocation.	PRACTICAL.	TECHNICAL.	GENERAL.
Professional.	Medical Practitioner.	The Dissecting Table. The Clinic, the Hospital.	Chemistry, Materia Medica Anatomy. Physiology. etc.	Medical Jurisprudence. Medical Sociology, etc.
	Teacher.	The Practising School.	Methods of Teaching. School Management. Child Psychology, etc.	History of Education. Educational Systems,. Reformers, etc.
Commercial.	Clerk.	Book-keeping. Stenography and Typing. Business Practice.	Commercial Arithmetic. Commercial Geography. Commercial Law. Modern Languages, etc.	History of Commerce. Political Economy. Mathematics of Actuarial Computation, etc.
Industrial.	Engineers' Mechanic.	The Bench. The Lathe. Other Power Tools.	Practical Mathematics. Applied Mechanics. Steam Machine Drawing, etc.	The Iron & Steel Industry. Lives of Inventors. Trade Unionism & Industrial Co-operation, etc.
	Gardener.	The Nursery, Green House and Garden.	Botany, Chemistry of Soils and Manures. Simple Entomology and Insecticides. Perspective Drawing, etc.	Historic Gardens. Japanese Horticulture Landscape Architecture. Colour Schemes. Plant Evolution. Mendelism, etc.
Domestic.	Wife and Mother.	The Kitchen. The Laundry. The Sewing-room. The Nursery Crèche.	Weights. Measures and Money. Simple Science of Foodstuffs. Common Adulterants and Preservatives. Household Hygiene Motherhood and After-care. Civics, etc.	Higher Literature. Historic Homes. An Art-craft. Domestic Economy. Eugenics. Child Psychology, etc.

The Technology of the Vocation. — Vocational Culture.

Vocational Efficiency.

actually working in them as a probationer before a final choice is made. In all these points the young person requires the guidance and advice of a specialist, who is acquainted with the general abilities of the pupil before the choice is ratified by the parents. The first step will be taken on the advice of the child's teacher at the end of the primary or ordinary school course; that guidance will be limited, naturally, to the divisions of labour in which the child as a future worker may be fairly expected to reach the maximum expression of its final development; that is, whether the aim should be to the professional, the commercial, or the industrial division. The natural avenue to the professions is through the secondary or high school, and thence through a university college; to commercial life, through the commercial school; and to industrialism, through a suitable trades school. The next step will come as to the particular branch of the division chosen, that will be taken on the advice of the principal of the vocational institution the pupil is then attending.

In the trades school the pupil should be actually engaged in the workshop, workroom, field or garden where the simpler stages of productive work are begun, but under the conditions of actual production. The phase of the training should be such as to require trade clothing, trade hours, trade standards of production, trade associations as far as possible, knowledge of the trade cost of the production, and, possibly, a sharing of the value of his (or her) output.

Being thus in contact with actual reality, some part of the time should be set aside for the study of the technical and more theoretical side of the trade now being followed. Here, however, it is essential that such necessary subjects as mathematics, applied science, art, history and civics for citizenship, should not require such a style of presentation as to detach them from the pupil's experience. This has undoubtedly been a serious mistake in many schools and continuation classes for supplemental education. There has been too great a gulf between the experience of the pupil and the school studies—too few points of contact for real vocational efficiency. The curriculum of the trades school must give the pupil manual dexterity with a knowledge of tools, processes and materials gained through actual practical work carried out under trade conditions as nearly as possible—one of such conditions being that the instructor must be a qualified tradesman with a certain amount of teaching ability. From the class-room instruction a further knowledge of materials, methods, trade calculations and trade drawing must be obtainable. Other class-room subjects would be technical mathematics, to the extent required in the industry in which a beginning as a worker is being made, and the applied science upon which the principles of the trade depend. Added to these would be such general subjects as office practice, geography of the world mainly as regards the production and transportation of raw materials, history and civics as a guide to citizenship.

The ideal ought to be to train for a trade as though it were a profession—to educate "the whole boy"; to do more than merely produce workers who will render more efficient service to their employers, and to do this by instruction in the relation of the individual to the community, in his civic function, in the laws relating to personal and communal hygiene—in addition to offering the pupils a reasonable prospect of maintaining themselves in adult life.

Almost every possible variation in vocational schools has been tried. A big company will maintain its own technical institute where its apprentices are expected to attend for a certain number of hours on certain evenings in the week. Groups of workers may be brought together for a weekly talk by a sub-manager. The advantages are that the instruction given is direct; it can be adapted to every requirement of the particular business; it is by far the most successful way of getting quick results for a given business. The objections are that the vocational education given is incomplete; it deals wholly with the kind of employé that the employer wants and the training that he requires, which may mean that that worker is wholly or partially unemployable elsewhere; in other words, it is not able to assume the disinterested attitude of the publicly controlled form; the point of view is limited to the creation of a potential wage earner or producer. Another method has been that certain firms have paid the fees of their apprentices, and even given them a bonus for a certain minimum attendances at certain specified evening classes; this is probably one of the worst ways of all; in the first place the employer had but a questionable right of dismissing an employé who did not attend the classes; secondly, those who did attend did that and nothing more, probably because "too easy getting makes the prize seem light"—they had not to pay fees, and the acquirement of technical knowledge was not necessary in order to be employed as apprentices since they were already so employed under a signed agreement. There is no need to point out the disadvantages and drawbacks of attending evening classes after a full day's labour in the works; again, many looked for a rate of progress entirely impossible on the pupils present educational ability whatever his previous attainment may have been. We are forced to the conclusion that voluntary systems are useless unless they are arranged to intercept the pupil as he leaves the primary school and *before* he gains the employment he desires—*i.e.,* before the consummation of his young ambition. Yet another variety is the "half-time" system, of which the best results are to be found in South Germany; in England it has usually been "half-time" at the "wrong-time," and for an insufficient period itself confined to the continuation of an unfinished ordinary school education. The National Advisory Board has pointed out that hitherto many of our experiments in vocational education have tended to be obscured by the "poor white problem." To help the poor is a

traditional impulse, and is justifiable if the aim of the help is to obviate the need of charity; vocational education can do much in this direction for the dependent and the delinquent through that type of institution known as the industrial school. It is, however, "the normal boy and girl of the non-indigent classes" that form the greater national asset, and to whom we must afford every opportunity to develop their working power with the least waste to themselves and to the State. For these, trades schools are necessary as separate institutions.

Other countries have long provided for the ordinary boy or girl who is unable to go on to the secondary school as a means of learning a trade. As early as 1857 Holland established its first trades school in Amsterdam; there are now over forty such schools throughout the length and breadth of that country. The most complete of these is the *Ambachtschool No.* 3, in the magnificent new building on the Timorplein in Amsterdam. It has accommodation for 1,000 boys, and it was full in 1914. These are pure trade schools and not merely "technical institutes," as we understand them; specific trades are taught by tradesmen instructors to boys who have completed the ordinary or elementary school course; each boy enters at about 14 years of age, and the course covers three years; many boys remain for a fourth year. The trades taught include house-decorating and painting, masons' work, plastering and bricklaying, carpentry, cabinetmaking, electrician's work, and the trade of engineer's mechanic. Related school subjects are taught both for vocational efficiency and citizenship, the standard of the instruction in these subjects being partly a revision of the elementary school course, and partly secondary in treatment. There is no compulsion, the pupil is free to come or go as he pleases; but no employer, no matter how small his way of business, will take an apprentice unless he can produce the standard trades school certificate. The surprising thing is that such small towns as Alkmaar, Tiel, and Apeldoorn* have equally complete trades schools, but, of course, of smaller pupil-capacity; it must not be thought that these are government forced institutions; on the contrary, they are established by a species of local option, and the expenditure is met—one-third by the municipality, one-third from the Education Vote, and the remaining third from the Royal Treasury Funds—the source of revenue in all cases being the taxes. These boys' schools are parallelled by similar and other institutions for girls. The most completely equipped domestic school is undoubtedly the *Huishoudt School voor Meisjes* in Amsterdam; built in the newer residential quarter about two years ago to accommodate some 30 boarders, this institution is a kind of higher grade domestic science school for the daughters of the more well-to-do; among many excellent features, mention must be made of the physiology class-room,

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* Nos. of inhabitants, roughly: Amsterdam, 590,000; Apeldoorn, 38,500; Alkmaar, 21,500; Tiel, 11,400.

where the arrangements for instruction to *girls* of the meaning of maternity and motherhood could not offend the susceptibilities of the most correct.

The type of vocational school that would be more generally suited to this country's needs is represented by the School of Rural Housekeeping at Bouchout—now most likely a shelled ruin—in gallant Belgium; here girls from fifteen to seventeen took turns at marketing for the school, took turns at cooking, and worked successively in the laundry, the garden, the poultry yard, and the dairy. The school was free and the length of the course was one year or according to the age of the pupil and her circumstances. Wherever one may go on the continent of Europe, whether to the Swedish and Danish* vocational high schools and farm schools involving practically no expense but board, to the higher commercial schools of Antwerp teaching its pupils commercial correspondence in at least three languages and where the most advanced course for the consular service is given, to the *Ferme Ecole* of France for peasants' sons, and her more advanced practical agriculture classes, to the *Ecole D' Horlogerie* at Geneva, where the famous Geneva Watch-making is taught; to the German *Ackerbauschulen*, where strong lads of seventeen not only receive free instruction, but some pay on completing the course—we find a curriculum planned for workers, carefully graded according to their promise of ability, and containing all the vocational fundamentals for efficient life.

No reference to the progress of vocational education in Europe would complete without the fullest consideration of what has been effected in Germany. The horror we feel at her recent actions as an avowed enemy must not prevent that examination of her educational progress in this one direction, which may enable us to defeat a more subtle form of invasion, the swamping of the local workers by foreigners of better vocational attainment. A Germany conquered is not a Germany vanished; the indemnity will have to be paid by her people; her birth-rate is high, and her seething population *must* find an outlet. How else than by emigration, by a reduced cost of production, by competition at home and abroad, but—preferably abroad? I write of things I have seen, and heed should be given to the warning "Mark over."†

The system of vocational education in Germany is supplementary, and is compulsory as soon as employment is obtained; this requires part-time attendance for eight to ten hours a week during the *day-time*,‡ for which the employer must pay wages as if the boy or girl were actually employed in the shop or counting-house. If the young employé has not completed the elementary day school course there is no admittance to trades

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* Skibbet Skole fur Skibs Kokke. Copenhagen, Ships' Cooks School.

† Enemy aeroplane approaching. Warning call in German South-West Africa.

‡ "Day" ends at 7 p.m. generally.

or commercial classes until he or she has qualified by attendance at a *Pflichtfortbildungsschule.**

Stringent regulations exist through which both employé and employer can be punished for contravention by fine or imprisonment. It may be that a conscript army has rendered possible the conscript continuation class and the iron discipline of the system; it began forty years ago, and has spread through the whole country as a nationally accepted system of education not, I think, because of conscription, but because it equips the ordinary individual with a vocational efficiency initially unexpected.

There is one great difference in the working of the systems as between, roughly, north and south Germany. In the south *trades* workshops are fitted in buildings specially provided for vocational teaching, while in the north the teaching is by theory illustrated by stereotyped samples and diagrams mounted on cards, the instruction being given by academically trained teachers from text-books prepared by a committee of each trade concerned, and in a class-room of the sort found in the older type elementary school. The older directors responsible for this system hold that the theory of the trade is all that need be imparted when the commercial shop practice actually engages the remaining time of the pupil. This has been a common argument in South Africa; here are three serious objections raised by German teachers themselves. The first and serious weakness is the impossibility of maintaining the interest of the pupil owing to the inelasticity and woodenness of the examples and problems that must be used in the teaching, this results in a deadening of the interest of the pupil during a particularly sensitive period of the child's education. The second and very serious weakness is the waste of time owing to an insistence upon obsolete teaching methods; for example, an apprentice class for dental mechanics is expected to be able to recite by rote the constituent proportions of certain teeth fillings, the chemical action that occurs in each, and how the work is done. Again, hygiene is supposed to be imparted by learning off certain rules upon the science and an examination of some wall pictures. The third and very serious weakness is that the lessons given often do not cover the individual practical difficulties that the apprentices meet with in their work; the difficulties referred to are those that depend, as a rule, upon the learner; but there are others, in addition, due to the fact that the apprentice may be employed by a master who is acting as a sub-contractor, and therefore the work done in his shop does not cover the whole practice of the trade. This last point became crucial as soon as the academically trained teacher was replaced by a qualified tradesman instructor, which usually occurred in the third or last year of the course, and because the apprentice often outran the teacher

* Compulsory Continuation Ordinary School Classes in the afternoon.

in his handling of a practical trade subject. This state of chaos was remedied by the semi-insurgent class being handed over to the *Meister,** who taught in the *Geselle* or journeyman class. This man is a modern past-master in his trade; managers of the *Fachfortbildungschulen*† see to that. He was at variance with parts of the official instruction books, and could give valid reasons for his departure from the strict line; he knew more than many of the smaller employers, and was at once able to group the class according to the quality of their practice in the trade; he saw that more than half his class had not seen the practice of the point under discussion, and he introduced models and pieces of his own work; there were still some dull brains in his class, and the next step was simple: he put them to work with such scrap material as he could find. The old adage "that an ounce of practice is worth a ton of precept" was justified: Hercules had cleansed the Augean stable! The discussion between the managers was heated, and the authorities were unsympathetic, but he won in the end, and the *Fachschulen* are to adopt the methods of South Germany by basing the instruction upon demonstration, teaching and practice in workshops as an integral part of the vocational school.

The centre of the South German system is Munich; here under the guidance of Dr. Kerschensteiner the system has been perfected to a very high pitch. Munich has something over fifty trades, for which teaching is given, with over ten thousand boys and nearly an equal number of girls in attendance in well-equipped classes, and workshops all housed in splendid buildings. The success of the system may be gathered from the fact that from 1910 (?) onwards only 8 per cent. of the boys of Munich did not enter some skilled trade. Practical men direct almost all the sub-divisions of the commercial, painting and decorating, building, printing, mechanical engineering, wood and metal working trades, besides such miscellaneous ones as shoemaking, wigmaking, baking, confectionery, and so on. The teachers are men taken from the trade and taught to teach; the reverse process has not been found satisfactory, but, in the event of tradesman instructors not being forthcoming, academic teachers are given furlough on full pay in order to learn a trade for a time sufficiently long to master it for the more elementary stages of the teaching.. In the upper or advanced trades classes many of the instructors are part-time men, especially in applied art subjects like commercial photography and sculpture; in the case of stucco work an artist instructs as well as an artisan.

The age at which the selection of a trade is made would shock those who look upon the age of fourteen years as too early to begin to specialise; at about ten years of age the boys

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* The recognised grading in trades are, roughly: *Lerner*, apprentice; *Geselle*, journeyman; *Meister*, master workman.

† Compulsory Trades School, *Fachschulen* abbreviated form.

planning to enter the professions are separated from the others to go then or later on to what corresponds to our high schools; it is practically a social separation, and the two divisions practically never meet again. The others, including the "needy" ones, are then grounded in the use of tools on a system partaking partly of manual training methods and partly of definite handicraft instruction with the rudiments of mechanics. The girls of the same social status do simple clerking, a "needle" trade and house-keeping. These subjects are not taught in the ordinary class-rooms. In the "common" school in the new Siebold Strasse, excellent and completely-equipped workrooms exist for all these subjects together, with two fine bakeries equipped with the last word in modern ovens; in the grounds is a large school garden for both vegetables and flowers with poultry runs, the instruction being given by the caretaker, who lives with his family (as in all German schools) on the school premises. The boy in his last year as a pupil in the elementary or ordinary school course, who has made up his mind as to the trade he likes, usually finds employment either by enquiries conducted by himself or instituted by one of his parents; notices from employers requiring juvenile helpers, with or without pay, are addressed to the Principal* of the primary school, who affixes them to the school notice board. The parents seek the advice of the Principal, who consults the official census of occupations and employment, supplied him by the Ministerial Department of Trades and Industries, but refrains (by instruction) from exerting any influence on the choice of a trade.

The management of vocational education for juveniles beyond the age of fourteen is vested in a board distinct from that managing the ordinary elementary or primary school, and consisting of employers, master and journeymen members of the various trades guilds, representatives of various public commercial bodies, one or more educational officials, and often the principal teachers. This ensures that the interests of all concerned receive consideration, namely, workers, employers and teachers.

The system of teaching and the system of control both indicate clearly that the trades schools of Holland have supplied the model for the day trade continuation classes of Munich, the main difference being that the Dutch boy gets his vocational training *before* he goes to employment, and from age 14 to age 17, continuing, after employment, in evening classes; while the German boy begins as soon after 10 years of age as possible, and *when he has obtained employment,* and continues until he has obtained from his guild† at least the journeyman's certificate of *Geselle,* usually between the ages of 21 to 25. The Munich system has spread to Austria, and is being established

* *Direktor* in German.

† The German Trade Union which includes both employers (if qualified) and men.

in Switzerland. In Vienna there is a magnificent five-storey building in the Pragerstrasse which is a veritable vocational palace. The completeness of the arrangements may be gathered from the fact that in each of the four corners of this pile is an electric lift, any one of which is capable of transporting a class of forty from the basement to the top floor, as, for example, when the stone-dressing or plastering classes are required to attend the art class in the glazed and domed halls in the roof. It is not some trades that are taught, but literally every one about the town where the school is, even to waiters and cabmen.

Britain still relies largely upon the voluntary evening school and the voluntary technical school, but these institutions, admirable as they are, do not deter at least nine-tenths of the children from turning their backs upon avoidable knowledge at fourteen. Industry is entrenched, business is powerful, and it still seems to employers a long step to countenance a compulsory system of part-time schools in working hours, for which they have to pay. The child whose parents can afford that it shall stay a year or two longer without wage-earning, can get day-training, but most apprentices must get their vocational training increased by attendance at night classes. Many day trades schools have been established throughout England, but these, in the thoroughness of the trade training given, lag considerably behind the same institutions in Holland. Many of them, indeed, give but a preliminary training in general wood and metal work, such as is obtainable in the Munich schools after the age of ten. There are others, however, and, of these I saw, I must mention the excellent School of Photo Engraving and Process Block Production (London County Council) at Bolt Court, London, where boys are given a three-year course, or until employment, which fits them for employment as improvers; the equally excellent schools of girls' trades at the Borough Polytechnic, London, S.E., and lastly, the newer Stanley Trades School at Norwood, London, S.E., where boys are given a two-years' school and workshop course as engineers' mechanics, fitting them for employment as leading apprentices in the various power tool-making works along the Thames. That these schools are a success is due, I am confident, to the fact that the curriculum is controlled by master craftsmen and women with the trades instructors staff in the ascendant; those schools are weak in vocational result where the headship is academic with an academic teaching staff holding the power.

I have shown in the diagram (p. 701) the children from various kinds of school passing through the Juvenile Employment Bureau into the labour market. In Britain this is a Government institution which, although its officials have little or no proper information about children's occupations, is doing good work by acting as a clearing house between the employer with a vacancy and the unemployed young worker. In Edinburgh this work is undertaken by the School Board; all teachers are supplied with

cards of the card-filing system pattern; when a pupil intimates that he or she is leaving school for good, certain particulars are entered on the card, which is then sent to the offices of the Board, and there collated and cross-indexed with others.

Any applications to the Board from employers for juvenile assistants are intimated to likely ex-pupils in the order of receipt of their cards. Pupils are invited to report the progress of their search for employment to their teachers, and they are also expected to notify the Board when they have been successful, with the nature of the employment taken up. As soon as this has been done, the parents and the pupil are advised of the desirability of attending continuation classes; suitable subjects of study are suggested, and the name of the nearest school or institution in which tuition is given is forwarded. The name and address of the young employee is sent to the headmaster of the school named, and he writes inviting the pupil to call for advice. In this way the Edinburgh School Board have compiled valuable statistics, while succeeding in making the evening continuation courses as vital and successful as may be expected of such a voluntary system. The Board believe in the shop system of vocational instruction, and have equipped eighteen workshops for the additional instruction of apprentices employed in different trades. These are night classes (held in a special building on open ground at Tynecastle), but the Board are extending the ground plan in preparation for the time when continuation teaching by daylight will be accepted as compulsory. The progressive members frankly discuss the possibility under the Scotch Education (1908) of allowing half-day employment, only, between the ages of fifteen and eighteen, which would force up local wages by diminishing the supply of boy and girl labour.

The system required for South Africa is the day trades schools of Holland, *previous to employment,* and the Munich system of daylight continuation classes *concurrently with employment.* I do not advocate compulsion; I do not think that machinery could be found to give anything like full effect to the compelling clauses of an Act. I think it reasonable to expect that the various unions of trades and associations of employers should give the effect of compulsion, as is done in Holland, by demanding from each juvenile a trades school certificate, and by basing further promotion upon attendance at vocational—not merely technical—continuation classes. The difficulties in connection with vocational education, and particularly trades schools, are many. For some time to come we may expect vocational education to continue its present tendency to be academically theoretic and bookish, unless there is a frank recognition that technical studies must blend intimately with the practice of the trade to which they refer, unless there is that close correlation between trade practice and trade theory which alone can produce an effcient technology. It is admitted that the time is not yet when a standard type of vocational education can be

laid down that will include all trades. What the exemplary systems I have quoted prove is, that it is indispensable for complete vocational efficiency that the vocational school should reproduce all the practical and theoretical conditions necessary in the trades it teaches, and that every trade requires such vocational school; that is, to develop facilities for the acquisition of practical experience in the schools themselves. To achieve this end the proposed school must have the atmosphere of a workshop rather than of a school. In the length of day, shop surroundings, disposal of products, the training of teachers, and the maintenance of discipline, shop and office standards rather than school standards must prevail, and approach, gradually, those of productive industry. Herein lies one difficulty; teachers must abandon a variety of traditions common to the schoolmaster and inherent to the administration of the ordinary school; a new series of educational values is required, because the practical work already outlined involves teaching methods and an administration fundamentally different from that found in most existing schools, especially in connection with the training of youth between the ages of fourteen and eighteen. The next administrative difficulty is that of providing, under public school conditions, for a wide range of trades with their expensive equipment; the probability is that this can be dealt with by grouping similar trades together with the compilation of a common syllabus of work, through which, with a sufficient variety of alternative projects or operations, the future worker can obtain a sufficiently practical and fundamental training, and without sacrificing trade methods. The next difficulty is with regard to the disposal of products, since the idea of the trades school involves the idea that the output should have a commercial value. It is vocationally uneconomical for pupils to be confined to unproductive exercises, and their efforts could be greatly stimulated if the things made could be sold, partly to the profit of the school, and partly to the profit of the pupil-worker. The advantages of the school, however, must not be used to the detriment of outside producers. Here the practice of similar institutions elsewhere may be useful. The trades schools of Holland hold bi-annual, sometimes triennial, lotteries for the disposal of the made articles. The Munich schools are not allowed to sell anything produced in their workshops. The articles made belong to the person or body supplying the material; if the school supplies the material, the school is the owner, and if an employer provides stuff, he is the owner—and so on. As the syllabus of the course of instruction has been prepared by trades committees for each workshop, and as these are adhered to, there is no abuse as might exist if a small employer supplied a quantity of material in order to obtain certain articles "on the cheap." In any event, it would seem that the total output of such schools must be small relatively to the market, and provided sales are conducted in such a way as not to disturb prevailing prices, there should be small danger in this

connection. There is the difficulty of providing for the variety of callings as has been mentioned; in addition, there is another—that of adapting the courses, in degree as well as in aim, to the different capacities and needs of those desiring vocational training; this means many changes in initial ideas regarding the organisation of the courses of instruction, length of training, etc. The necessities disclosed by experience must be considered and provided for. Yet another difficulty is the want of adequate text-books and other guides to instruction; it is likely that each school, to a considerable extent, may have to work out special syllabuses suited to local conditions, and draft a system of notes for the pupils, which may, after the test of time, become the printed text-book.

Lastly, there is another market that the trades school products might disturb, the labour market; in nearly every trade the organisations of the adult workers has succeeded in establishing certain standards of remuneration, and this wages level appears to be greatly dependent upon a certain limitation in the supply of qualified workers. It is conceivable that trades schools might co-operate to swamp the labour market in one particular trade, although to do so would be likely to inflict serious injustice upon its own pupils; the solution of this difficulty undoubtedly lies in the careful consideration of supply and demand, as it will affect the future of the pupil on leaving the school. If, therefore, the future conditions in any trade are considered with a view to the prevention of undue hardship upon the young worker, that consideration is likely to serve equally the interest of the adult worker in competition with younger ones. In this connection the example of Holland should again be followed by making the school committees equally representative of employers and employés. It must be remembered that the object of vocational schools *must* be to provide vocational training for as many boys and girls as possible, in the conviction that the presence in the community of a large number of unemployables, from insufficient training, or of unemployed—through overstocking the market—is highly injurious to society; all that can be said is that what is likely to be the larger social need at the time of leaving school must control the administration.

The expansion of vocational education must be constantly interpreted as a productive and justifiable form of social investment to increase human power; it involves protection of labour heretofore largely exploited, and nothing more important in this direction has been undertaken since elementary or ordinary education was made compulsory. The educational policy of all civilised countries has been distinctly opposed to the principle of individualism as inefficient and otherwise undesirable; elementary, secondary, and—to some extent—higher liberal education has been made freely available to the youth of the community, and it has pursued this policy partly out of regard for the in-

dividual—and, possibly, for a particular class of individual—but largely by the spirit of higher social self-preservation.

But even now the total outlay for education is but an insignificant part of the total social expenditure, yet that outlay is probably one of the most effective for the social good ever devised. It would be interesting to compare the social expenditure upon advertising—which, though necessary, can scarcely be described as so socially productive as education. The State has fostered in the past public professional schools and colleges, normal training colleges for teachers, schools for military instruction, and those for higher agricultural work and the engineering professions, and it has made vocational education a part of its contribution to dependent and delinquent children; it is now engaged upon the question of general vocational instruction through the National Advisory Board for Technical Education, and it behoves every parent and every person with the social good at heart to demand, and to bear a share in meeting the cost of, efficient vocational education by daylight based upon the best of all forms of compulsion—the will of the people.

THE RAND GOLD.

By Prof. Ernest H. L. Schwarz, A.R.C.S., F.G.S.

(*Printed in "The South African Mining Journal," July*, 1915.)

EXPERIMENTS IN CROSSING PERSIAN AND MERINO SHEEP.

By Joseph Burtt-Davy, F.L.S., F.R.G.S.

(*Not printed.*)

PYORRHÆA ALVEOLARIS: SOME EXPERIMENTS AND THEIR RESULTS.

By F. W. FitzSimons, F.Z.S., F.R.M.S.

(*Not printed.*)

NOTES ON THE FUNCTIONS OF COLOUR IN CERTAIN SOUTH AFRICAN REPTILES AND AMPHIBIANS.

By J. H. Power.

(*Not printed.*)

THE REAL OBJECT OF NATURAL SCIENCE.

By Norman Mudd, M.A.

[*Abstract.*]

The formulation of some general account of scientific knowledge which can be subscribed to by all scientists, which can be comprehended by the scientific layman, and which shall enable him to understand the one or two things he really requires to know about science, is one of the most urgent duties of modern scientists, and one of the most present public needs. What is wanted is some such account of scientific knowledge as shall make comprehensible to the scientific layman what is the philosophic status of science, in order that he may have some means of judging what importance to attach to it in his general thinking. The object of this paper is to clear some of the ground as a necessary preliminary to the construction of such a general statement.

In spite of much misuse, the term "science" and "scientific" have quite definite meanings when used by careful writers, meanings which may be summarised in the following definition: "By science we mean a body of knowledge and assertion constructed from past experience by induction, and capable of being tested by observation and experiment." The suggestions which I shall put forward in this paper are concerned with science as delimited by this definition.

Now if we start with this definition of science, it seems to me that whatever the actual contents of science may be at any time, the following universal principles must hold:—

1. Scientific assertions are all, in logical intention, conditional promises, which, when translated out of their technical language, are of the form: "If you do so and so, you will find so and so—*i.e.*, you will see, hear, taste, smell, or what not, some specified sensible quality." Scientific knowledge is the knowledge of what these promises should be, and of the grounds on which they are made.

2. Scientific assertions possess, therefore, that sort of certainty which always attaches to promises, *i.e.*, save at certain instants, when their truth or falsity may be known with a certainty that passes all doubt, they possess no certainty and no finality. They are merely waiting to be tested.

3. Scientific assertions are limited, with absolute strictness as regards their reference, to things which can be perceived by the senses.

The first of these principles, that all scientific assertions are really conditional promises of things to be perceived, is to my mind quite the most fundamental fact about science. To conceive science in this way as a sort of empirical prophecy, makes clear, without the need of formal demonstration, such matters

as that of the nature of scientific certainty (stated in the second principle), and that of the limitation of scientific knowledge as regards scope (third principle).

This doctrine as to the logical form of all scientific assertions seems to follow at once from the definition of science, as soon as we ask ourselves what sort of assertions are they which observation and experiment serve to test. If a mere observation serves to test an assertion, to reveal it as true or false, it can only be because the assertion, whatever its form, is an assertion as to what would be the result of such an observation. Consider again an experimental observation. This is an observation or inspection following on an operation of some sort, and if a procedure like this tests an assertion, it can only be because the assertion is a statement as to what would be observable as the result of that operation. The principle, therefore, as to the nature of all scientific assertions is a mere translation into logical terms of the conceptions of observation and experiment.

Let me give one or two very simple examples of the translation of statements from the technical language of science into conditional promises expressed in ordinary language.

Consider the following two statements. (*a*) A point P moves with constant velocity. (*b*) If a point P is initially at A, and one second later at B, then at any other instant, say *n* seconds after passing through A, it will be found in the position C, where C is on A B and A C is *n* times A B. These two statements are logically equivalent. Either may be deduced from the other by processes of purely formal logic, once the logical definition of the technical term *velocity* is known. The difference between them is that one is expressed in highly technical scientific language which hides its logical form, the other is expressed in ordinary language which reveals its intention as a conditional promise.

Consider next the following pair of statements. (*a*) The specific gravity of lead is 9.2. (*b*) Let a piece of lead be applied in any definite manner to a deformable system, and let some reading of this system taken in any definite manner be noted. Then if we apply to the system in the same manner a quantity of standard water whose volume is 9.2 times that of the lead, the reading produced will be found to be the same as before. Here, again, the two statements are logically equivalent, but the second is of such a form that its logical intention as a conditional promise is apparent.

Now unfortunately a mere description of the philosophic nature of science is inadequate as an answer to the more important question as to whether the influence of science on human thinking has limits. The reason is that it *may* be doubted whether *all* our knowledge is not in reality of the form "If you do so and so, etc." It may be doubted, that is, whether all our knowledge is not scientific in form, and destined to actual conquest by organised science.

There is at present in vogue in philosophic and scientific circles a doctrine known as pragmatism, which is in effect the theory that all intelligible knowledge and assertions are scientific in their nature. Pragmatism states itself as a theory of truth, namely, that all truth consists in a sort of working. Now this seems to me to imply that the meaning or intention of all assertions must be *a promise of such working,* which is exactly the same sort of thing as the meaning or intention of a scientific assertion. I propose, therefore, to inquire whether there are or are not intelligible assertions and regions of knowledge which are not scientific, and to which the pragmatic theory of truth does not apply.

In the case of a scientific assertion, its truth and the working of a belief in it are identical. If, for example, the predictions of celestial events based on the theory of universal gravitation radically failed to come off, then the doctrine would *ipso facto* cease to be true. The reason is that the whole meaning and intention of the theory, once its technical language is understood, is seen to be that predictions of this sort should come off, that the doctrine should work in this way.

Similarly, any belief whatever works to some extent in some sense or senses, and probably fails to work to some extent in other senses, and just in so far as it can be tested by observation and experiment, the working of a belief is one of the most important things about it. People do, as a matter of fact, accept or reject beliefs almost entirely on the score of their working or not working.

Now the pragmatist asserts that the working or not working of a belief is not merely one particular aspect of it, but is its very essence and meaning, that the working of a belief and its truth are indistinguishable. He asserts that the truth of an assertion consists in its pragmatic working, and that it is meaningless to think of truth in any other way. I am convinced that as a general statement this doctrine is false.

The primary reason why we are concerned in some cases to mean by truth something radically different from any sort of working is that the world of our interests transcends immeasurably that world of our mere acquaintance, actual or potential, which is open to our inspection. We are interested, and vitally interested, in things which lie together outside the universe of things that work. Further, it is in general true that our higher interests, our passionate interests, are almost entirely simple direct interest in things which do, by their nature, transcend our acquaintance and inspection.

Let us fix our impressions by considering certain passions, properly so called, such as jealousy, indignation, pity. The more we reflect on these passions, especially if we refer to some vivid instance in our own experience or in imaginative literature, the more we shall see, I think, that the objects which these passions

contemplate are metaphysical objects which lie beyond the world of our possible acquaintance and inspection.

Let us suppose, for instance, that we are ordinary sensitive and human people, and are deeply revolted at the idea of dogs being tortured for our profit, whether by vivisectors or others. Now the intellectual foundation of our attitude is the quite metaphysical belief that dogs do feel pain. It is a belief that cannot be verified or tested, it is a belief which can be, and has been, denied by various philosophers on various grounds. The pain, if it exists, transcends completely our possible acquaintance and inspection. And if the assertion that dogs feel pain is made, it is made as an act of faith. Now it is this assertion which touches so nearly our passions, and not any recognition of the fact that the assertion works in various ways. The assertion does work, of course, in various pragmatic ways, and discussion about the truth of the assertion is usually merely a discussion of how it works. Thus, all the dog's behaviour suggests it, any religious theory suggests and asserts it, any theory of evolution suggests it, scores of fine poems and moving stories would be unintelligible without it. The assertion does, therefore, most emphatically work, and the recognition of this is important, and gives mental ease and intellectual backing in our belief. But any such facts of working are utterly alien from our intention when we make the simple assertion: "Dogs feel pain." The question as to whether the doctrine *works* is one that may leave us troubled, dissatisfied, intellectually doubtful indeed. But the question as to whether the doctrine is *true, i.e.*, as to whether dogs do feel pain, is one about which our passions are moved in an altogether different way.

The inadequacy of the pragmatic theory of truth is best seen, therefore, in the case of doctrines about which we are easily moved. It is necessary to be passionately interested in a doctrine in order that the utter difference between what we mean by its truth, and what the pragmatists assert we mean, may appeal to us with full force. If the dogma of the existence of God is for us merely an academic intellectual question, it is comparatively easy for a sophist to convince himself, and us, that its truth means and consists in the fact that it works, the fact, for instance, that it comforts people and gives them strength, and allows them to take moral holidays. But it is not possible to talk in this manner to a passionate believer, the peace of whose soul is bound up in the dogma. The same is true of any metaphysical assertion whatever. It is metaphysical or non-scientific, because its reference transcends in some way the world of possible acquaintance and inspection, and for anyone to whom it is in itself a passionate and vital concern, the pragmatic suggestion is wholly inadequate.

THE INTRUSIONS IN THE GRANITE OF PARYS, ORANGE FREE STATE.

By Prof. SAMUEL JAMES SHAND, PH.D., D.Sc., F.G.S.

[*Abstract.*]

The granite of Parys is intersected by a network of apparently intrusive veins of a dense black rock, having the appearance of tachylyte. Close study in the field and in the laboratory shows that in some respects this material differs from a normal igneous glass, and it is thought that it represents a " melt " of granite, produced by mechanically developed heat. The question was discussed fully, and the nature of the intrusions was illustrated by photographs and drawings.

A second type of intrusion in the same district is shown by a great dyke, nearly 600 yards in width, of a granophyric quartz-dolerite.

A full account of the phenomena has been communicated to the Geological Society of London.

PRELIMINARY LIST OF SOUTH AFRICAN FUNGI, REPRESENTED IN THE MYCOLOGICAL HERBARIUM, PRETORIA.

By ILTYD BULLER POLE-EVANS, M.A. B.Sc., F.L.S., and Miss A. M. BOTTOMLEY, B.A.

(*Not printed.*)

ON A METHOD OF MAKING PERMANENT PREPARATIONS OF SUPERFICIAL FUNGI.

By ETHEL MARY DOIDGE, M.A., D.Sc., F.L.S.

(*Not printed.*)

NOTES ON SOME OF THE SOUTH AFRICAN *STAPELIÆ*.

By Miss S. M. STENT.

(*Not printed.*)

ON THE PRESERVATION OF THE MONUMENTS OF NATURE.

By HERMANN GOTTFRIED BREYER, PH.D.

(*Not printed.*)

SOME NOTES ON THE SOUTH AFRICAN ALOES.

By Iltyd Buller Pole Evans, M.A., B.Sc., F.L.S.

(Not printed.)

OBSERVATIONS ON THE EVOLUTION OF BIRDS; WITH SPECIAL REFERENCE TO SOUTH AFRICAN FORMS.

By Austin Roberts.

(Not printed.)

ANTI-VENOMOUS SERUM AND ITS PREPARATION.

By F. W. FitzSimons, F.Z.S., F.R.M.S.

(Not printed.)

THE LITERATURE OF FRANCE DURING THE GREAT REVOLUTION.

By Prof. Renicus Dowe Nauta.

(Not printed.)

FOUR MONTHS IN SLAVIC AUSTRIA.

By Rev. William Alfred Norton, B.A., B.Litt.

(Not printed.)

PROPORTIONAL REPRESENTATION.

By Ralph Kilpin.

(Not printed.)

TRANSACTIONS OF SOCIETIES.

South African Society of Civil Engineers.—Wednesday, May 10th, Prof. A. E. Snape, M.Sc., A.M.I.C.E., M.R.San.I., President, in the chair.—"*Run-off at Dutoitspan*": W. **Newdigate** and Dr. J. R. **Sutton.** Dutoitspan is one of the most important of the dams and vleis round about Kimberley: the catchment area has been enlarged from time to time, and ranged from 12.5 square miles in 1905 to 26 square miles in 1915. The percentage of run-off decreased from 7.7 in 1905 to 5.0 in 1915, the decrease being mainly due to the softer ground intersected by the water courses at a distance from the pan. The more intense the rainfall, the greater was the run-off: thus, the run-off on 37 occasions on which the rainfall was .5 in. or less averaged 3.1 per cent. The average was 7.7 on six occasions when the rainfall ranged from 1.51 to 2.00 inches, and on one occasion a rainfall of 3.02 inches resulted in a 19.6 per cent. run-off.—"*Construction and costs of reinforced concrete flume at Van Wyksdorp, C.P.*" Full details were recorded of the construction of a flume 60 feet long, in Anthus Kloof, a steep-sided water-course crossing the canal of the Buffelsfontein Irrigation Scheme. The total cost of the structure was £115.

Wednesday, June 14th: Prof. A. E. Snape, M.Sc., A.M.I.C.E., M.R.San.I., President, in the chair.—"*Notes on Town-Planning*": D. E. **Lloyd-Davies.** The author directed his remarks in particular to the application of town-planning to the requirements of Greater Capetown. In this connection the most urgently-needed regulations were indicated, and a number of suggestions made for improvement of the general outline.—"*Methods of measuring work*": H. J. **Walker.** In view of the necessity for an engineer engaged on the construction of a railway line to have at his command quick and accurate methods of measuring up works, the author described the methods which he had adopted in respect of banks and cuttings, classification of material, booking the measurements and making calculations from the field entries.

Royal Society of South Africa.—Wednesday, May 17th: A. M. Wilson, M.D., B.S., M.R.C.S., L.R.C.P., Vice President, in the chair.—"*Œcological Notes on the District of Manubie, Transkei*": W. T. **Saxton.** The area comprises three chief plant formations, namely, woodland, park-like grassland, and sedge vegetation. The soil, a fine red brown loam, is essentially uniform throughout the area. No marked differences in climatic or edaphic factors distinguish the woodland from the grass land, though these are of strikingly different appearance, and are separated by a sharp boundary line. (*a*) "*Note on the Radiations emitted by degenerating tissues*"; (*b*) "*Note on the Ionisation produced by degenerating nerve-muscle preparations*": J. S. **van der Lingen.** Organic tissues may *post mortem* give rise to ionisation, which can be detected by the discharge of an electroscope. On the second and third days after death the discharge seems to attain its maximum. Radiation seems to be given off which can affect photographic plates.

Wednesday, June 21st: L. A. Péringuey, D.Sc., F.E.S., F.Z.S., President, in the chair.—"*Note on Protective Resemblance in post-larval stages of some South African Fishes*": Prof. J. D. F. **Gilchrist.** In *Hemiramphus calabaricus* the post-larval stages of the fish have the size and colour of fragments of weed, which are found in the waters which the young fish frequent. When alarmed, the fish become rigid and float about in an apparently inanimate condition. It is then difficult to distinguish them from the floating pieces of weed. In Klipfish (*Clinus* spp.) the young are born alive, and they are of a clear glassy transparency difficult to detect in the water. The contour of the body is probably disguised by a number of minute dark dots.—"*On the Morphology of the Female Flower of Gnetum*": Prof. H. H. W. **Pearson.** Diverse views recently put forward on the structure of the flower of the Gnetales were discussed in detail and compared with special reference to the author's own investi-

gations.—"*Heart rot of* Pteroxylon utile (*Sneezewood*) *caused by* Fomes rimosus *Berk.* Dr. P. A. **van der Byl.** The distribution of the fungus (*Fomes rimosus* Berk) and the effect it has on the wood of *Pteroxylon utile* were recorded. This fungus has thus far been reported in the Union of South Africa on 11 genera belonging to eight different natural orders. The fungus attacks a large number of trees belonging to different orders.

South African Institute of Electrical Engineers.—Thursday, May 18th: Prof. W. Buchanan, M.I.E.E., President, in the chair.—"*Notes on Generating Station Reports*": V. **Pickles.** The author described the method of recording station reports adopted by the Victoria Falls Power Company, Johannesburg.

Chemical, Metallurgical, and Mining Society of South Africa.—Saturday, May 20th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair.—"*On some diseases of the respiratory organs incidental to miners, as portrayed by Agricola in* 1550.": Dr. J. **de Fenton.** Centuries ago, lesions of the lung due to particles of dust—in other words, silicosis, or miners' phthisis—were known to exist among certain classes of mine workers, and the description given by Agricola definitely connotes that disease.

Saturday, June 24th: J. E. Thomas, A.I.M.M., M.Am.I.E.E., President, in the chair.—"*The encouragement of first-aid work on the mines; some suggestions based on experience at the Crown Mines, Ltd.*": A. J. **Brett.** An account was given of the scheme which had been carried into operation at the Crown Mines, with a view to arousing increased interest in first-aid work on the mines.

South African Association of Analytical Chemists.—Thursday, June 22nd: J. Moir, M.A., D.Sc., President, in the chair.—Presidential address: J. **Moir.** The author laid stress on the unfortunate position which the chemist occupies in the mind of the Government and the public, due entirely to their ignorance of the importance of the chemist. It was therefore necessary to educate them to a proper appreciation of the profession. The necessity of research in South Africa and the paucity of the country's industries were also pointed out.

OFFICERS AND COUNCIL, 1915-1916.

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Rev. W. Flint, D.D., Librarian of Parliament, Capetown.
Lieut.Col. J. Hyslop, D.S.O., M.B., C.M., Medical Superintendent, Government Asylum, Maritzburg.
J. Orr, B.Sc., M.I.C.E., Professor of Engineering, South African School of Mines and Technology, Johannesburg.
Sir A. Theiler, K.C.M.G., D.Sc., Director of Veterinary Research, Pretoria.

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C. F. Juritz, M.A., D.Sc., F.I.C., Government Chemical Laboratory, Capetown.
H. E. Wood, M.Sc., F.R.Met.Soc., Union Observatory, Johannesburg.

HON. GENERAL TREASURER.

A. Walsh, P.O. Box 39, Cape Town.

ASSISTANT GENERAL SECRETARY.

H. Tucker, Cape of Good Hope Savings Bank Buildings, St. George's Street, Cape Town. P.O. Box 1497. (Telegraphic Address: "Scientific.")

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J. Lunt, D.Sc., F.I.C.
R. W. Menmuir, A.M.I.C.E.
A. H. Reid, F.R.I.B.A., F.R.San.I.

Grahamstown.

Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.

Kimberley.

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A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.

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Port Elizabeth.

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Prof. E. J. Goddard, B.A., D.Sc.

II. TRANSVAAL.

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J. Burtt-Davy, F.L.S., F.R.G.S.
W. A. Caldecott, B.A., D.Sc., F.C.S.
P. Cazalet.
W. Ingham, M.I.C.E., M.I.M.E.
Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.
J. A. Vaughan.
Prof. J. A. Wilkinson, M.A., F.C.S.

Pretoria.

I. B. Pole Evans, M.A., B.Sc., F.L.S.
F. E. Kanthack, M.I.C.E., M.I.M.E.
D. Kehoe, M.R.C.V.S.
Prof. D. F. du Toit Malherbe, M.A., Ph.D.

Potchefstroom.

E. Holmes Smith, B.Sc.

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Prof. T. M. Forsyth, M.A., D.Phil.
Dr. W. Johnson, L.R.C.P., L.R.C.S.

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A. McKenzie, M.D., C.M., M.R.C.S.
G. T. Plowman, C.M.G.
Prof. W. N. Roseveare, M.A.
Prof. E. Warren, D.Sc.

V. RHODESIA.

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VI. MOZAMBIQUE.

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LIST OF MEMBERS

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1ST JULY, 1916.

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* Indicates Foundation Members (30th June, 1902).
† Indicates Life Members.
Names of **PAST PRESIDENTS OF THE ASSOCIATION** are Printed in **THICK CAPITALS.**
Names of MEMBERS OF COUNCIL for the 1915 Session are printed in SMALL CAPITALS.
Names of Members whose addresses are incomplete or not known are printed in *italics.*

Members are requested to notify the Assistant General Secretary (P.O. Box 1497 Cape Town) of any changes in address, or additions which may be necessary as soon as possible.

Year of Election.

1902. †à-Ababrelton, Robert, F.R.G.S., F.R.E.S., F.S.S., Royal Institute, Northumberland Avenue, London, W.C.
1902. *Aburrow, Charles, P.O. Box 534, Johannesburg.
1905. Adamson, John E., M.A. (Pres. D, 1915), Education Department, Pretoria.
1904. Aiken, Alexander, P.O. Box 2636, Johannesburg.
1904. Ainsworth, Herbert, P.O. Box 1553, Johannesburg.
1915. †Akerman, Conrad, M.A., M.B., B.C., Conethmoar, Alexandra Road, Pietermaritzburg.
1905. Albu, Sir George, P.O. Box 1242, Johannesburg.
1913. Alexander, William, A.M.I.C.E., A.R.T.C., South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1910. ANDERSON, ALFRED JASPER, M.A., M.B., D.P.H., M.R.C.S., City Hall, Capetown.
1902. *Andrews, G. S. Burt, M.I.C.E., M.I.Mech.E., M.S.A., P.O. Box 1049, Johannesburg.
1914. Angus, David, P.O. Box 230, Kimberley.
1914. Anstey, Norman, P.O. Box 1003, Johannesburg.
1903. Arnold, Frank Arthur, M.B., D.P.H., L.S.A., P.O. Box 211, Pretoria.
1908. Arnott, William, Gas Works, Port Elizabeth, C.P.
1904. Auret, A. A., P.O. Box 838, Johannesburg.
1915. Austin, Robert Gordon Lefroy, M.A., Transvaal Education Department, P.O. Box 432, Pretoria.

Year of Election.

1913. Bachmann, Carl, Dynamite Factory, Modderfontein, Transvaal.
1906. Bailey, Sir Abe, Kt., P.O. Box 50, Johannesburg.
1902. *Baker, Herbert, F.R.I.B.A., Exploration Buildings (165-8), P.O. Box 4959, Johannesburg.
1903. †Balmforth, Rev. Ramsden, "Shirley," 6, Stephen Street, Capetown.
1913. Barbosa, Joâo Tamagnini de Souza, Engineer, Inhambane. Province of Mozambique.
1911. Barratt, Gaston Frederick Sharpe, Bembezaan, Queque, Southern Rhodesia.
1911. Barratt, Rowland Lorraine, Bembezaan, Queque, Southern Rhodesia.
1905. †Basto, H. E. Alberto Celestine Ferreira Pinto, 95, Rua Luiz-de-Camoes, Lisbon, Portugal.
1903. †Baxter, William, M.A., South African College School, Capetown.
1902. *†Beattie, John Carruthers, D.Sc., F.R.S.E. (Pres. A., 1910), Professor of Physics, South African College Capetown.
1915. Bedford, Gerald Augustus Harold, F.E.S., Veterinary Research Laboratory, Onderstepoort, P.O. Box 593, Pretoria.
1913. Beerstecher, Leonard, P.O. Box 2888, Johannesburg.
1916. Bews, John William, M.A., D.Sc., Professor of Botany, Natal University College, P.O. Box 375, Pietermaritzburg.
1910. Bisset, James, M.I.C.E., M.R.San.I., Beauleigh, Kenilworth, Cape Division.
1905. Blackshaw, George N., B.Sc., F.C.S., Analytical Laboratory, Department of Agriculture, Salisbury, Rhodesia.
1915. Blundell, Frederick Moss, 308, Orient Street, Arcadia, Pretoria.
1906. Bohle, Hermann, M.I.E.E., Corporation Professor of Electrotechnics, South African College, Capetown.
1911. Bolus, Charles Arthur, 20, Steytler's Buildings, P.O. Box 232, Johannesburg.
1905. †Bolus, Mrs. F., B.A., Sherwood, Kenilworth, near Capetown.
1913. Bonn, Adalbert L. M., C.E. (Pres. C, 1913), P.O. Box 204, Lourenço Marques.
1913. Botelho, Lieut. Joâo Baptista, Chief Veterinary Officer, Department of Agriculture, P.O. Box 255, Lourenço Marques.
1906. Bourne, A. H. J., M.A., Principal, High Schools, Kimberley, C.P.
1913. Bracht, Oscar, P.O. Box 134, Port Elizabeth, C.P.

Year of Election.

1915. Brain, Charles Kimberlin, M.A., M.Sc., Division of Entomology, Pretoria.

1902. *Braine, Charles Dimond Horatio, A.M.I.C.E., Devon Pen, Holmdene, Transvaal.

1915. Breyer, Hermann Gottfried, Ph.D., Director of the Transvaal Museum, P.O. Box 413, Pretoria.

1914. Brierly, James D., Department of Agriculture, Bloemfontein.

1910. Brill, J., Litt.D., L.H.D., Ph.Th.M., Lorothwana, 65, Park Road, Bloemfontein.

1905. Brincker, J. C. H., c/o The Montagu Co-operative Wines, Ltd., Montagu, C.P.

1914. Brinton, Arthur Greene, F.R.C.S., L.R.C.P., F.R.S.M., P.O. Box 4397, Johannesburg.

1910. Britten, Gilbert Frederick, B.A., Government Chemical Laboratory, Capetown.

1903. Brown, Alexander, M.A., B.Sc., F.R.S.E., Professor of Applied Mathematics, South African College, Capetown.

1914. Brown, Rev. Holman, P.O. Box 82, Bulawayo, Rhodesia.

1910. Brown, John, M.D., C.M., F.R.C.S., L.R.C.S.E., 14, Liesbeek Road, Rosebank, C.P.

1907. Brown, William Bridgman, M.A., Griffithville, Queenstown, C.P.

1913. Browne, Rowland F., A.M.I.C.E., P.O. Box 432, Lourenço Marques.

1909. Brownlee, John Innes, M.B., C.M., Alexandra Road, Kingwilliamstown, C.P.

1912. Brümmer, Rev. Prof. N. J., M.A., B.D., Victoria College, Stellenbosch, C.P.

1902. *Buchan, James, Assistant Resident Engineer, Rhodes Buildings, Bulawayo.

1916. Bull, Henry Walter, 352, Burger Street, Pietermaritzburg.

1916. Buntine, Robert Andrew, M.B., B.Ch., M.L.A., Pietermaritzburg.

1905. Burroughs, Herbert John, 10A, Clarence Street, Troyeville, Johannesburg.

1903. †Burtt-Davy, Joseph, F.L.S., F.R.G.S., P.O. Box 1148, Johannesburg.

1903. Caldecott, W. A., B.A., D.Sc., F.C.S., P.O. Box 67, Johannesburg.

1902. *†Campbell, Allan McDowell McLeod, B.A., Resident Engineer, South African Railways, Bandolier Kop, Transvaal.

1916. Campbell, Samuel George, M.D., M.Ch., F.R.C.S.E., M.R.C.S., D.P.H., 28, Musgrave Road, Durban.

1908. Carlson, K. A., Forestry Division, Department of Agriculture, Bloemfontein.

Year of Election.

1913. Carvalho, José J. d'A., Chief of Naval Services, P.O. Box 262, Lourenço Marques.

1910. Cattell, E. J., Chamber of Commerce, Capetown.

1916. Cawston, Frederick Gordon, B.A., M.B., B.C., M.R.C.S,. L.R.C.P., 147, Loop Street, Pietermaritzburg.

1903. †CAZALET, PERCY, P.O. Box 1056, Johannesburg.

1906. †*Champion, Ivor Edward (address wanted).*

1914. Chandler, Right Rev. Arthur, M.A., D.D., Bishop of Bloemfontein, Bishop's Lodge, Bloemfontein.

1913. Charters, Robert Hearne, M.I.C.E., Professor of Civil Engineering, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1903. Clark, John, M.A., LL.D., Arderne Professor of English Language and Literature, South African College, Capetown.

1916. Clayton, Emily Jane Mason, 100, Market Street, Pretoria.

1916. Clephan, Ethel Hunter, Girls' High School, Park Street, Pretoria.

1903. Cohen, Walter P., F.R.P.S., Hon. Sec., Johannesburg Field and Naturalists' Club, P.O. Box 68, Johannesburg.

1908. Collie, J., c/o the Administrator, South-West African Protectorate, Windhuk.

1904 Collins, Ernest A. E., 66, Pritchard Street, P.O. Box 723, Johannesburg.

1914. Collins, Louis Napoleon Buonaparte, P.O. Box 723, Johannesburg.

1906. Collins, M. R., Irrigation Department, P.O. Box 399, Pretoria.

1915. Cooke, Howard, B.S.A., Grootfontein School of Agriculture, Middelburg, C.P.

1904. Cooper, Fred W., Public Library, Port Elizabeth, C.P.

1915. Cordiner, William Smallie, 121, Loveday Street, Wanderers' View, Johannesburg.

1914. Cory, George Edward, M.A., Professor of Chemistry and Metallurgy, Rhodes University College, Grahamstown.

1904. †Coutts, John Morton Sim, M.D., L.R.C.P., D.P.H., M.R.C.S. Britstown, C.P.

1916. Cox, George Walter, F.R.Met.S., P.O. Box 399, Pretoria.

1902. *†Cox, Walter Hubert, Royal Observatory, near Capetown.

1909. Crawford, David Chambers, M.A., B.Sc., B.Sc.Agr., Elsenburg, Mulder's Vlei, C.P.

1902. *†CRAWFORD, LAWRENCE, M.A., D.Sc., F.R.S.E. (PRESISIDENT), Professor of Pure Mathematics, South African College, Capetown.

1916. Cruden, Frank, Alicedale, C.P.

Year of Election.

1903. †Cullen, William, M.I.M.M. (General Secretary, 1905-1908), British South Africa Explosives Co., Ltd., 612, Salisbury House, Finsbury Circus, London, E.C., England.
1903. Currie, O. J., M.B., M.R.C.S., Claremont, near Capetown.

1913. Da Silva, Colonel Pedro Luiz de Bellegarde, Surveyor-General of Mozambique, P.O. Box 288, Lourenço Marques.
1905. Dale, Hubert, P.O. Box 632, Johannesburg.
1903. Dalrymple, Hon. W., P.O. Box 2927, Johannesburg.
1915. Dalton, John Patrick, M.A., D.Sc., Professor of Mathematics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1913. Damant, E. L., P.O. Box 1176, Johannesburg.
1913. Daniel, John, Armley House, 30, Plein Street, Johannesburg.
1910. Davenport, William John, P.O. Box 1049, Johannesburg.
1903. Davies, J. Hubert, M.I.E.E., M.I.Mech.E., A.M.I.C.E., P.O. Box 1386, Johannesburg.
1903. Davis, Frederick H., B.Sc., M.I.E.E., P.O. Box 1934, Johannesburg.
1916. Daymond, William Henry, P.O. Nigel, Transvaal.
1916. De Fenton, John, Ph.D., Seymour Memorial Library, P.O. Box 2561, Johannesburg.
1915. De Klerk, Arie, 486, Schoeman Street, Pretoria.
1915. De Kock, Gilles van de Wall, M.R.C.V.S., Veterinary Research Office, P.O. Box 593, Pretoria.
1914. De Kock, Dr. Servaas Meyer, P.O. Box 321, Bloemfontein.
1913. Delbridge, William John, A.R.I.B.A., P.O. Box 120, Capetown.
1915. Delfos, Cornelis Fredrik, P.O. Box 24, Pretoria.
1904. Delmore, Dr. J. Schlesinger, P.O. Box 1455, Johannesburg.
1915. De Villiers, C. G. S., 681, Pretorius Street, Arcadia, Pretoria.
1915. De Villiers, Louis Celliers, Ph.D., M.E., Lecturer in Geology and Mineralogy, Transvaal University College, Pretoria.
1915. Dick, Colonel James, St. Thomas Road, Durban.
1909. Dodt, J. J., National Museum, Bloemfontein.
1915. Doidge, Ethel Mary, M.A., D.Sc., F.L.S., P.O. Box 1294, Pretoria.
1911. Dornan, Rev. Samuel S., M.A., F.G.S., P.O. Box 510, Bulawayo.
1908. Drège, Isaac Louis, P.O. Box 148, Port Elizabeth, C.P.
1914. Dreyer, P., Civil Commissioner, Civil Commissioner's Office, Kimberley.

Year of Election.

1915. Dreyer, Thomas F., B.A., Ph.D., Grey University College, Bloemfontein.
1906. Druce, P. M., M.A., The College, Potchefstroom, Transvaal.
1902. *Drury, Edward Guy Dru, M.D., B.S., D.P.H., Grahamstown, C.P.
1915. Du Boulay, Alice Mary Houssemayne, Transvaal Education Department, Pretoria.
1913. Du Toit, A. E., M.A., Professor of Mathematics, Transvaal University College, Pretoria.
1915. Du Toit, Pieter Johannes, Under-Secretary for Agriculture, Union Buildings, Pretoria.
1906. Duerden, James E., M.Sc., Ph.D., A.R.C.S., Professor of Zoology, Rhodes University College, Grahamstown, C.P.
1915. Dumat, Henry Aylmer, M.D., F.R.C.P.E., 7, Devonshire Place, Durban, Natal.
1910. Duncan, A., P.O. Box 1214, Johannesburg.
1904. Duncan, Patrick, C.M.G., Sauer's Buildings, Johannesburg.
1909. Dunkerton, Edward B., c/o Messrs. Lennon, Ltd., West Street, P.O. Box 266, Durban, Natal.
1911. †Duthie, George, M.A., F.R.S.E. (Pres. D. 1911), Director of Education, Salisbury, Rhodesia.
1912. Dwyer, E. W., B.A., 192, Walker Street, Pretoria.

1916. Eadie, Duncan MacIntyre, 669, Currie Street, Durban, Natal.
1904. Eaton, William Arthur, 74, St. George's Street, Capetown.
1909. Edwards, Charles J., c/o Messrs. Heynes Mathew & Co., P.O. Box 242, Capetown.
1914. Elsdon-Dew, William, M.I.E.E., P.O. Box 4563, Johannesburg.
1910. †Engelenburg, Dr. F. V., Editor, *De Volksstem*, Pretoria.
1910. Erskine, J. K., F.C.S., Willowdene, near Johannesburg.
1905. †Evans, Iltyd Buller Pole, M.A., B.Sc., F.L.S., (Pres. C.), Chief of the Division of Plant Pathology, Department of Agriculture, P.O. Box 1294, Pretoria.
1905. Evans, Maurice Smethurst, C.M.G., F.Z.S. (Pres. D), Hillcrest, Berea Ridge, Durban, Natal.
1905. †Evans, Samuel, 153, Nuggett, Street, Johannesburg.
1914. Eveleigh, Rev. William, 28, Gladstone Avenue, Kimberley, C.P.
1904. Ewing, Sydney Edward Thacker, M.I.E.E., P.O. Box 3, Brakpan, Transvaal.
1906 Eyles, Frederick, F.L.S., M.L.C. (Pres. C., 1911), Umsasa Farm, P.O. Mazoe, Rhodesia.

Year of Election.

1915. Fairbridge, William Ernest, P.O. Box 1014, Johannesburg.
1905. Farrar, Edward, P.O. Box 1242, Johannesburg.
1914. Farrow, Frederick Denny, M.Sc., Rhodes University College, Grahamstown, C.P.
1905. Feetham, Richard, Sauer's Buildings, c/o Loveday and Market Streets, Johannesburg.
1915. Ferreira, Frederick Herbert, Resident Magistrate's Office, Herschel, C.P.
1915. Fielden-Briggs, H., M.D., L.D.S., F.C.S., P.O. Box 1213, Johannesburg.
1915. Findlay, George Schreiner, 151, Esselen Street, Pretoria.
1913. Fischer, Christian Ludwig, B.A., 9, Ryneveld Street, Stellenbosch, C.P.
1913. FitzHenry, Rev. J., Bedford, C.P.
1912. FitzSimons, F. W., F.Z.S., F.R.M.S. (Pres. C. 1912), Director, Port Elizabeth Museum, Port Elizabeth, C.P.
1902. *Flack, Rev. Francis Walter, M.A., The Rectory, Uitenhage, C.P.
1902. Flanagan, Henry George, F.L.S., Prospect Farm, Komgha, C.P.
1902. *†FLINT, Rev. WILLIAM, D.D. (Vice-President; Pres. D., 1910), Wolmunster Park, Rosebank, C.P.
1902. *Flowers, Frank, C.E., F.R.G.S., F.R.A.S., P.O., Box 1878, Johannesburg.
1909. Fogarty, Rev. N. W., Director, Government Industrial School, Maseru, Basutoland.
1907. Foote, J. A., F.G.S., F.E.I.S. (Pres. D, 1913), Principal, Commercial High School, Plein Street, Johannesburg.
1914. Ford, Thurston James, Secretary, De Beers Benefit Society, Kimberley, C.P.
1914. FORSYTH, THOMAS M., M.A., D.Phil., Professor of Philosophy, Grey University College, Bloemfontein.
1914. Forsyth, Mrs. T. M., Eagle's Nest, P.O. Box 238, Bloemfontein.
1916. Fouché, Carl Hercules, M.A., P.O. Box 1176, Johannesburg.
1905. †Frames, P. Ross, P.O. Box 148, Johannesburg.
1906. †Frankenstein, Miss Adelia, B.A., 9, Knight Street, Kimberley, C.P.
1915. Franklin, Leonard Joseph, African Banking Corporation, 4, Steyn Street, Bloemfontein.
1916. Fraser, John, J.P., P.O. Box 149, Pietermaritzburg.
1902. Fremantle, Henry Eardley Stephen, M.A., F.S.S., M.L.A., Bedwell Cottage, Rosebank, C.P.
1913. Frew, John, P.O. Box 1, Johannesburg.
1912. Friel, Robert, M.A., M.D., P.O. Box 144, Potchefstroom, Transvaal.
1916. Frood, George Edward Bell, M.A., M.I.M.M., Mines Department, Bloemfontein.

Year of Election.

1914. Frood, Dr. T. M., Rand Club, Johannesburg.
1902. *Fuhr, Harry A., A.M.I.C.E., Public Works Department, Kingwilliamstown, C.P.
1904. Fuller, W. H., Chairman, Public Library, East London, C.P.

1907. Gairdner, Dr. J. Francis R., 754, Church Street, Arcadia, Pretoria.
1903. †Galpin, Ernest Edward, F.L.S., c/o National Bank of South Africa, Ltd., Queenstown, C.P.
1913. Garbutt, Herbert William, F.R.A.I., J.P., P.O. Box 181, Bulawayo, Rhodesia.
1915. Garlick, Miss Winifred Marguerite, Thornibrae, Green Point, Capetown.
1902. *†Gasson, William, F.C.S., Dutoitspan Road, Kimberley, C.P.
1915. Gatherer, John Frederick William, P.O. Box 433, Bloemfontein.
1904. Gellatly, John T. B., M.I.C.E., P.O. Box 37, Bethulie, O.F.S.
1912. Gibson, Harry, J.P., F.S.A.A., P.O. Box 1653, 85, St. George's Street, Capetown.
1902. *Gilchrist, John Dow Fisher, M.A., D.Sc., Ph.D., F.L.S., (GENERAL SECRETARY, 1903-1908), Professor of Zoology, South African College, Capetown.
1903. Gilchrist, W., M.S.A., Mariendahl, Mulder's Vlei, C.P.
1916. Gill, Harold Warren, B.Sc., F.I.C., P.O. Box 1176, Johannesburg.
1902. *Gillespie, John, A.M.I.C.E., Railway Construction, Idutywa, Transkei, C.P.
1910. Ginsberg, Franz, M.P.C., P.O. Box 3, Kingwilliamstown, C.P.
1912. GODDARD, ERNEST JAMES, B.A., D.Sc., Professor of Zoology, Victoria College, Stellenbosch, C.P.
1913. Goddard, Mrs. E. J., Stellenbosch, C.P.
1902. †Godfrey, Rev. Robert, M.A., Somerville Mission, Tsolo, C.P.
1904. Gorges, Edmond Howard Lacam, M.V.O., Administrator, South-West African Protectorate, Windhuk.
1915. Gould, Robert Howe, P.O. Box 4941, Johannesburg.
1913. Graça, Captain Alberto C. de Faria, Sub-Chefe de Estado Major, Quartel Geral, P.O. Box 485, Lourenço Marques.
1915. Graham, George Smith, Avondale, P.O. Box 40, Queenstown, C.P.
1908. Grant, Charles C., M.A., Education Department, Bloemfontein.
1914. Grant, William Frank, B.Sc., South African College High School, Capetown.

Year of Election.

1907. Gray, Charles Joseph, Office of Inspector of Mines, P.O. Box 405, Krugersdorp, Transvaal.
1907. Gray, James, F.I.C., P.O. Box 5254, Johannesburg.
1915. Green, Henry Hamilton, B.Sc., F.C.S., Veterinary Laboratory, Onderstepoort, P.O. Box 593, Pretoria.
1906. Grimmer, Irvine Rowell, Assistant General Manager, De Beers Consolidated Mines, Ltd., Kimberley, C.P.
1912. Gubbins, John Gaspard, B.A., Ottoshoop, Transvaal.
1913. Gundry, Philip G., B.Sc., Ph.D., A.R.C.S., Professor of Physics, Transvaal University College, Pretoria.
1915. Gunn, David, P.O. Box 1013, Pretoria.
1911. Guradze, Dr. Franz, Vice-Consul for Germany, German Consulate, Capetown.
1905. †Gutsche, Phillipp, M.D., Villa Torrita, Kingwilliamstown, C.P.
1903. Gyde, Charles J., Public Works Department, Capetown.

1904. Haagner, Alwyn K., F.Z.S., Zoological Gardens, P.O. Box 754, Pretoria.
1904. †Haarhoff, Daniel Johannes, J.P., Market Street, Kimberley, C.P.
1902. * **HAHN, PAUL DANIEL**, M.A., Ph.D. (PRES. A, 1903, PRESIDENT, 1911), Jamison Professor of Chemistry and Metallurgy, South African College, Capetown.
1907. Hall, Carl, A.M.I.C.E., F.G.S., 28, Club Arcade, Durban, Natal.
1910. Halm, Jacob K. E., Ph.D., F.R.S.E., Royal Observatory, C.P.
1907. Hammar, August, 441, Burger Street, Pietermaritzburg, Natal.
1902. *Hancock, H., A.M.I.C.E., P.O. Box 192, Klerksdorp, Transvaal.
1903. †Hancock, Strangman, M.Amer.I.M.E., Kennel Holt, Cranbrook, Kent, England.
1916. Hardenberg, Christiaan Bernhardus, M.A., New Hanover Rail, Natal.
1904. Harries, W. M., P.O. Pox 2189, Johannesburg.
1905. Harris, Lionel, M.E., B.Sc., 113, Sivewright Avenue, Doornfontein, P.O. Box 1311, Johannesburg.
1915. Harrison, Charles William Francis, F.R.G.S., F.R.S.S., Nel's Rust, Natal.
1915. HARRISON, ERNEST, M.S.Agr., B.Sc., Government School of Agriculture, Cedara, Natal.
1914. Harvey, Sidney Francis, P.O. Box 1386, Johannesburg.
1916. Hastings, Isabel, Wykeham School, Pietermaritzburg.
1905. Hatchard, John George, F.R.A.S., Longview, Shannon, P.O. Box 499, Bloemfontein.

Year of Election.

1914. Henderson, Miss J., c/o Dr. J. B. H. Ruthven, P.O. Box 6253, Johannesburg.

1902. *Henkel, John Spurgeon, Conservator of Forests, Pietermaritzburg.

1904. †Herdman, G. W., M.A., M.I.C.E., Public Works Department, P.O. Box 439, Pretoria.

1911. Hewetson, W. M., M.B., D.P.H., J.P., Wankie, Southern Rhodesia.

1909. Hewitt, John, B.A., Director of the Albany Museum, Grahamstown, Cape.

1915. Hewitt, Strafford Smith, P.O. Box 192, Bloemfontein.

1905. Heymann, Alexander, M.Ph., M.Ch., M.A., P.O. Box 3427, Johannesburg.

1909. Heymans, Dr. G. M. A., 702, Church Street, Arcadia, Pretoria.

1916. Higham, Joseph, B.Sc., Sunnyside, York Road, Parktown, Johannesburg.

1916. Hodges, Ruth Mary, B.Sc., Wykeham School, Pietermaritzburg.

1914. Holdsworth, W. J., P.O. Box 1737, Johannesburg.

1913. Holgate, V. G., P.O. Box 1176, Johannesburg.

1905. Holm, Alexander, Department of Agriculture, Pretoria.

1915. Honey, Thomas, Superintendent, Municipal Gardens, P.O. Box 403, Lourenço Marques.

1902. †Honnold, W. L., Hyde Park Hotel, 66, Knightsbridge, London, S.W., England.

1902. *Horne, William James, A.M.I.C.E., A.M.I.E.E., Educacation Department, P.O. Box 432, Pretoria.

1905. Hosking, Charles, 434, Marshall Street, Belgravia, Johannesburg.

1902. *†Hough, Sydney Samuel, M.A., F.R.S., Astronomer Royal, Royal Observatory, C.P.

1914. Howitt, A. Gordon, B.Sc., Civil Service Club, Capetown.

1910. Hughes, George Robert, Under-Secretary for Lands, Pretoria.

1905. †Humphrey, William Alvara, B.A., Ph.D., F.G.S., Vryheid, Natal.

1912. Hunt, Donald Rolfe, Sub-Native Commissioner, Secocoeniland, *via* Lydenburg, Transvaal.

1904. **HYSLOP, JAMES**, D.S.O., M.B., C.M. (Vice-President, PRESIDENT, 1907), The Huts, Pietermaritzburg, Natal.

1913. Hutcheon, James, M.A., F.R.S.G.S., Rosedale, South African College School, Capetown.

1913. INGHAM, WILLIAM, M.I.C.E., M.I.M.E., Chief Engineer's Office, Rand Water Board, P.O. Box 1703, Johannesburg.

1907. Innes, Hon. Justice Sir James Rose-, K.C.M.G., B.A., LL.B., High Court of Appeal, Capetown.

Year of Election.

1902. ***INNES, ROBERT THORBURN AYTON**, F.R.A.S., F.R.S.E. (GENERAL SECRETARY, 1909-1912; PRESIDENT, 1915), Union Observatory, Johannesburg.

1905. Innes, Mrs. R. T. A., Union Observatory, Johannesburg.

1908. Institute of Government Land Surveyors, Cape of Good Hope Savings Bank Buildings, Capetown.

1914. Jacot, Edouard, B.A., Lecturer in Physics, South African College, Capetown.

1916. Jackson, Hon. Justice Cecil Gower, 185, Prince Alfred Street, Pietermaritzburg.

1915. Jackson, Harry Percival, M.Sc., Jeppe High School, Johannesburg.

1915. Jackson, Percy, 28, Floss Road, Kensington, Johannesburg.

1904. Jagger, J. W., F.S.S., M.L.A., P.O. Box 258, Capetown.

1915. Janse, Antonius Johannes Theodorus, F.E.S., Lecturer in Biology, Normal College, Pretoria, 1st Street, Gezina, Pretoria.

1911. Jarvis, E. M., F.R.C.V.S., Jelf Estate, Umtali, Rhodesia.

1910. Jeffrey, John, Standard Bank, P.O. Box 57, Capetown.

1916. Jenner, Alice, Girls' High School, Oudtshoorn, C.P.

1903. Jennings, Hennen, 2221, Massachusetts Avenue, Washington, U.S.A.

1913. Jensen, Axel Emil, 36, Maddison Square, Jeppestown, Johannesburg.

1912. Johnson, Miss Alta, New Street, Wellington, C.P.

1912. Johnson, George Lindsay, M.A., M.D., 5 and 6, Castle Mansions, Eloff Street, Johannesburg.

1909. JOHNSON, W., L.R.C.P., L.R.C.S., 3, Link Road, Bloemfontein.

1914. Johnson, W. S., M.A., Professor of English, Grey University College, Bloemfontein.

1915. Jolly, William Adam, M.B., Ch.B., D.Sc., Professor of Physiology, South African College, Capetown.

1911. Jones, Ernest Hope, Control and Audit Office, Pretoria.

1911. Joubert, M. J., B.Sc.Agr., Department of Agriculture, Bloemfontein.

1905. †Junod, Rev. Henri A., P.O. Box 21, Lourenço Marques.

1903. †JURITZ, CHARLES FREDERICK, M.A., D.Sc., F.I.C. (Pres. B, 1909, GENERAL SECRETARY, 1910-1916), Government Analyst, Government Chemical Laboratory, Department of the Interior, Capetown.

1907. KANTHACK, FRANCIS EDGAR, M.I.C.E., M.I.M.E. (Pres. A, 1915), Director of Irrigation, Union Buildings, Pretoria.

1912. KEHOE, D., M.R.C.V.S., P.O. Box 593, Pretoria.

1915. Kelly, Albert, F.E.S., P.O. Box 513, Pretoria.

1903. Kent, Professor Thomas Parkes, M.A., South African College, Capetown.

Year of Election.

1915. Kenway, Harold Cecil, Public Works Department, Pretoria.
1905. King, Austin, Director of Mines, Macequeçe, Portuguese East Africa.
1915. King, Ethel Louise May, Eunice High School, Bloemfontein.
1915. King, Francis Edward, P.O. 802, Pretoria.
1914. Kingon, Rev. John Robert Lewis, M.A., F.L.S., United Free Church Mission, Ross, Umtata, C.P.
1913. Kirkland, John Wilkinson, M.Am.I.E.E., P. O. Box 1905, Johannesburg.
1907. Kirkman, John, J.P., M.P.C., 331, Musgrave Road, Durban.
1904. Kisch, C. H. M., P.O. Box 668, Johannesburg.
1915. Klooster, Willem, 576, Church Street, Arcadia, Pretoria.
1902. *†Knapp, Arthur D., Chikondi Estate, Neno Post Office, British Central Africa.
1902. Kolbe, Rev. Frederick Charles, B.A., D.D., St. Mary's Presbytery, Capetown.
1903. Kotze, Robert W. N., B.A., P.O. Box 1132, New Law Courts, Johannesburg.

1913. Landau, Nathan, Survey Office, Modder Deep Level, P.O. Box 376, Benoni, Transvaal.
1914. Lange, Hon. Justice Johannes H., LL.B., Judge's Chambers, Kimberley, C.P.
1913. Lansley, William G., P.O. Box 1485, corner Main and Donelly Streets, Kenilworth, Johannesburg.
1903. †Laschinger, E. J., B.A., P.O. Box 149, Johannesburg.
1904. †Leeds, R. Q., P.O. Box 928, Johannesburg.
1903. Legat, C.E., Department of Agriculture, Pretoria.
1907. Lehfeldt, Robert A., B.A., D.Sc. (General Treasurer, 1909-1910), Professor of Physics, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.
1908. Leighton, James, F.R.H.S., P.O. Box 86, Kingwilliamstown, C.P.
1908. Leiter, Miss Susan B., M.A., Huguenot College, Wellington, C.P.
1902. *Lenz, Otto, P.O. Box 92, Johannesburg.
1916. Leslie, Charles Duff, P.O. Box 1167, Johannesburg.
1916. †Leslie, Robert, M.A., F.S.S., Jagger Professor of Economics, South African College, Capetown.
1903. Leslie, T. N., C.E., F.G.S., P.O. Box 23, Vereeniging, Transvaal.
1908. Leviseur, M., Bloemfontein.
1903. †Lewis, Leon, P.O. Box 617, Johannesburg.
1905. †Lewis, Mrs. Helen R., P.O. Box 617, Johannesburg.

Year of Election.

1903. Logeman, William H., M.A., Professor of Physics, Grey University College, Bloemfontein.
1902. *Logeman, William Sybrand, L.H.C., B.A., Professor of French and German, South African College, Capetown.
1903. Lorentz, Henri, P.O., Box 55, Johannesburg.
1902. Lounsbury, Charles Pugsley, B.Sc., F.E.S., (Pres. C, 1915), Chief of the Division of Entomology, Department of Agriculture, P.O. Box 513, Pretoria.
1902. *LUNT, JOSEPH, D.Sc., F.I.C., Royal Observatory, C.P.
1914. Lyle, James, M.A., Grey College School, Bloemfontein.
1902. *Lynch, Major F. S., J.P., Kimberley Waterworks Co., Ltd., P.O. Box 630, Kimberley, C.P.

1908. Maasdorp, Hon. Justice Sir Andries F., 40, Elizabeth Street, Bloemfontein.
1905. †McArthur, Duncan Campbell, M.R.C.S., L.R.C.P., District Surgeon, Clanwilliam, C.P.
1905. McCallum, William, P.O. Box 4889, Johannesburg.
1909. Macdonald, G., M.A., Normal Training College, Bloemfontein.
1902. *McEwen, T. S., A.M.I.C.E., "The Links," Rondebosch, C.P.
1908. Macfadyen, William Allison, M.A., LL.D., Professor of Philosophy, Transvaal University College, Pretoria.
1909. McFeggans, Alexander, Umtata, C.P.
1914. McGregor, Rev. Andrew Murray, M.A., B.D., Blommestein, Three Anchor Bay, Capetown.
1904. McKENZIE, ARCHIBALD, M.D., C.M., M.R.C.S., Glen Lyon, Musgrave Road, Durban, Natal.
1903. Mackinlay, Andrew Grieve, C.E., M.S.I., District Engineer, South African Railways, Ladysmith, Natal.
1905. McLaren, W. A., P.O. Box 1209, Johannesburg.
1915. †McLoughlin, Alfred George, Chief Magistrate's Office, Umtata, C.P.
1914. Macmillan, William Miller, B.A., Drumclune, West Hill, Grahamstown, C.P.
1913. Macpherson, Henry Wingate, P.O. Box 4252, Johannesburg.
1908. Macrae, H. J., P.O. Box 817, Johannesburg.
1905. Madge, Captain Charles A., P.O. Box 4303, Johannesburg.
1914. Maitland, A. Gibb, F.G.S., Government Geologist of Western Australia, Bon Accord, 3, Ventnor Terrace, Perth, Western Australia.
1910. Malan, Hon. François Stephanus, B.A., LL.B., M.L.A., P.O. Box 450, Pretoria.
1912. †MALHERBE, D. F. DU TOIT, M.A., Ph.D., Professor of Chemistry, Transvaal University College, Pretoria.

Year of Election.

1914. Malherbe, Daniel François, B.A., Ph.D., Professor of Modern Languages, P.O. Box 424, Bloemfontein.
1904. Malherbe, H.L., P.O. Box 208, Pretoria.
1902. †Mally, Charles William, M.Sc., F.E.S., F.L.S., Division of Entomology, Department of Agriculture, Capetown.
1914. Mandy, George Stephen Thomas, Provincial Roads Department, Kokstad, C.P.
1915. Manning, Charles Nicolson, P.O. Box 98, Pietersburg, Transvaal.
1915. Marchand, Bernard de Coligny, B.A., D.Sc., Chemical Laboratory, Department of Agriculture, Pretoria.
1909. Marchand, Rev. Bernard P. J., B.A., Clairvaux, Rondebosch, C.P.
1914. Mardall, W. H., Johannesburg Consolidated Investment Co., Johannesburg.
1904. Marks, Samuel, Hatherley Buildings, P.O. Box 379, Pretoria.
1914. Marloth, Mrs. Marion M., Ellerborn, 7, Park Road, Capetown.
1902. *†**MARLOTH, Professor RUDOLF**, M.A., Ph.D. (Pres. B, 1903, PRESIDENT, 1914), P.O. Box 359, Capetown.
1904. †Marshall, W. S., P.O. Box 3055, Johannesburg.
1905. Martini, J. D., P.O. Box 34, Beira, Portuguese East Africa.
1911. Maufe, Herbert Brantwood, B.A., F.G.S., P.O. Box 168, Bulawayo.
1902. Melle, G. J. McCarthy, M.B., C.M., Robertson, Cape.
1903. Mellor, Edward, T., D.Sc., M.I.M.M., F.G.S., 5, New Law Courts, Johannesburg.
1902. *MENMUIR, R. W., A.M.I.C.E., National Mutual Buildings, Church Square, Capetown.
1914. Mesham, Paul, M.A., M.Sc., Natal University College, Pietermaritzburg, Natal.
1902.*†**METCALFE, Sir CHARLES**, Bart., M.I.C.E. (PRESIDENT, 1904; Pres. C, 1903), 21, Pall Mall, London, S.W., England.
1905. Miller, Allister M., The Swaziland Corporation, Ltd., Mbabane, Swaziland.
1911. Miolée, Willem Frederik, Consul for the Netherlands, P.O. Box 362, Bulawayo.
1915. Mitchell, David Thomas, M.R.C.V.S., Veterinary Research Office, P.O. Box 405, Department of Agriculture, Maritzburg, Natal.
1916. Mitchell, John, Jeppes Central Government School, Johannesburg.
1915. Mogg, Albert Oliver Dean, B.A., P.O. Box 1294, Pretoria.
1912. Moll, Dr. A. M., Kerk and Eloff Streets, Johannesburg.

Year of Election.

1904. Molyneux, A. J. C., F.G.S., F.R.G.S., (Pres. B, 1911), P.O. Box 526, Bulawayo, Rhodesia.
1903. Morice, Advocate George T., B.A., K.C., P.O. Box 1275, Pretoria.
1912. Mortimer, Dr. W., M.R.C.S., Potchefstroom, Transvaal.
1915. Mudd, Norman, M.A., Grey University College, Bloemfontein.
1902. ***MUIR, Sir THOMAS**, Kt., C.M.G., M.A., LL.D., F.R.S., F.R.S.E. (PRESIDENT, 1910), Elmcote, Sandown Road, Rondebosch, C.P.
1915. Munro, Hugh Kenneth, Division of Entomology, P.O. Box 513, Pretoria.
1913. Munro, James, P.O. Box 19, Lourenço Marques.
1904. Murray, George Alfred Everett, M.D., F.R.C.S., L.R.C.P., P.O. Box 105, Johannesburg.
1913. Murray, Myles Thornton, M.Sc., c/o Messrs. Muntz' Metal Works, French Walls, Birmingham, England.
1911. Musselwhite, Rev. E. W. H., B.A., Zonnebloem College, Capetown.

1916. Nance, Francis James, Office of Engineer-in-Chief, South African Railways, Johannesburg.
1916. Narbeth, Benjamin Mason, B.Sc., F.C.S., Principal, Technical College, Durban.
1910. Nauta, Prof. Renicus Dowe, South African College, Capetown.
1905. Neilson, A. M., Manager, Safco Fertilizers Co., Umbilo, Natal.
1915. New York Public Library, 42nd Street and Fifth Avenue, New York City, U.S.A.
1914. Newhall, Percy Melrose, B.Sc., P.O. Box 485, Johannesburg.
1913. Nicholas, Samuel John, P.O. Box 829, Johannesburg.
1902. *Nicholson, Colonel George Taylor, M.I.C.E., Resident Engineer Docks, Capetown.
1913. Nicol, John, M.R.C.V.S., Government Veterinary Surgeon, Kingwilliamstown.
1904. Nixon, Edward John, M.R.C.S., L.R.C.P., P.O. Box 57, Heidelberg, Transvaal.
1902. Nobbs, Eric Arthur, Ph.D., B.Sc., F.R.H.S., Director of Agriculture, Salisbury, Rhodesia.
1915. Norton, Rev. William Alfred, B.A., B.Litt., S. Augustine's Priory, Modderpoort, O.F.S.

1905. †Oats, Francis, F.G.S., Director, De Beers Consolidated Mines, Ltd., Kimberley, Cape Province.
1908. O'Connor, James, Railway Hotel and Stores, Ashton, Cape.

Year of Election.

1907. Ogg, Alexander, M.A., B.Sc., Ph.D. (Pres. A, 1914), Professor of Physics and Applied Mathematics, Rhodes University College, Grahamstown, C.P.

1904. O'Reilly, James Paul, P.O. Box 53, Johannesburg.

1915. Orenstein, Alexander Jeremiah, M.D., M.R.C.S., L.R.C.P., P.O. Box 1056, Johannesburg.

1914. Orford, Rev. Canon Horace William, M.A., Ficksburg, Orange Free State.

1906. Orpen, Joseph Millerd, Mon Asile, 43, St. Mark's Road, East London.

1902. *Orr, John, B.Sc., M.I.C.E. (Vice-President; Pres. A), Professor of Engineering, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1913. Orr, Mrs. J. c/o Professor Orr, P.O. Box 1176, Johannesburg.

1905. †Paisley, William, M.B., B.Ch., P.O. Box 127, Queenstown, Cape.

1908. Palmer, W. Jarvis, B.Sc.A., P.O. Box 477, East London, C.P.

1905. †Papenfus, H. B., K.C., P.O. Box 5155, Johannesburg.

1914. Parry, John, P.O. Box 220, Kimberley.

1912. Paterson, Mrs. T. V., Redhouse, near Port Elizabeth.

1902. *†Pattrick, C. B., A.M.I.C.E., 39, Kapteyn Street, Hospital Hill, Johannesburg.

1903. †Payne, Albert E., A.R.S.M., P.O. Box 15, Langlaagte, Transvaal.

1913. †Pearson, Henry Harold Welch, M.A., Sc.D., F.R.S., F.L.S., (Pres. C, 1910), Bolus Professor of Botany, South African College, Capetown.

1913. Pepulim, Dr. D., P.O. Box 704, Lourenço Marques.

1913. Perez, Manoel A. Jr., Chief Assistant, Observatorio Campos Rodriguez, Lourenço Marques.

1907. Péringuey, Louis Albert, D.Sc., F.E.S., F.Z.S., Director South African Museum, Capetown.

1910. †Perold, Abraham Izak, B.A., Ph.D., Principal, Government School of Agriculture, Elsenburg, Mulder's Vlei, C.P.

1912. Perrins, George Richard, "Grange," 106, Cape Road, Port Elizabeth, C.P.

1905. Petersen Carl Olief, P.O. Box 4938, Johannesburg.

1915. Pettey, Franklin William, B.A., Entomologist, Government School of Agriculture, Elsenburg, Mulder's Vlei, C.P.

1904. Pettman, Rev. Charles, Wesleyan Parsonage, Chapel Street, Kimberley, C.P.

1915. Phillips, Edwin Percy, M.A., D.Sc., F.L.S., South African Museum, Capetown.

Year of Election.

1912. Pickstone, Harry Ernest Victor, Lekkerwyn, Groot Drakenstein, C.P.

1903. Pim, Howard, B.A., F.C.A. (General Treasurer, 1906-1907), P.O. Box 1331, Johannesburg.

1915. Plowman, George Thomas, C.M.G., Provincial Secretary, Pietermaritzburg.

1915. Pollard, Miss Grace E., F.R.H.S., Huguenot College, Wellington, C.P.

1914. Pooley, John, F.S.A.A., F.R.C.I., P.O. Box 189, Kimberley.

1916. Pott, Ethel K. A., S. Cyprian's School, Annandale Street, Capetown.

1905. †Potts, George, M.Sc., Ph.D. (Pres. C, 1914), Professor of Botany, Grey University College, 91, Park Road, Bloemfontein.

1913. Provay, Giuseppe, Chief Electrical Engineer of Harbours and Railways, P.O. Box 1479, Lourenço Marques.

1910. Purcell, William Frederick, M.A., Ph.D., C.M.Z.S., Bergvliet, Diep River, C.P.

1906. Pym, Frank Arthur Oakley, Public Museum, P.O. Box 51, Kingwilliamstown, C.P.

1902. †Quinan, Kenneth B., Chemist and Engineer, Cape Explosive Works, Somerset West, C.P.

1903. Quinn, J. W., J.P., M.L.A., P.O. Box 1454, Johannesburg.

1915. Ramsbottom, Kathleen Nora, B.A., Eunice High School, Bloemfontein.

1906. Reid, Alexander William, M.D., C.M., Assistant Medical Officer of Health, City Hall, Capetown.

1902. *Reid, Arthur Henry, F.R.I.B.A., F.R.San.I., P.O. Box 120, Capetown.

1914. Reid, Walter, F.R.I.B.A., P.O. Box 746, Johannesburg.

1902. ***REUNERT, THEODORE**, M.I.C.E., M.I.M.E., (President, 1905), P.O. Box 92, Johannesburg.

1905. Reunert, Mrs. Theodore, P.O. Box 92, Johannesburg.

1907. Reuter, Rev. Fritz L., Medigen, P.O. Duivel's Kloof, *via* Pietermaritzburg, Natal.

1903. †Reyersbach, Louis J., 29 and 30, Holborn Viaduct, London, E.C.

1913. Reyneke, Andries Adriaan Louw, B.A., Durbanville, C.P.

1913. Reyneke, Rev. Jacobus Cornelius, De Pastorie, Cradock, C.P.

1904. Richardson, Sidney William Franklin, M.B., B.S., B.Sc., L.R.C.P., F.R.C.S., 2, Wale Street, Capetown.

1909. Rindl, Max Morris, Ing.D., Professor of Chemistry, Grey University College, Bloemfontein.

Year of Election.

1903. Ritchie, William, M.A. (Pres. D, 1914), Vice-Chancellor of the University of the Cape of Good Hope, South African College, Capetown.

1902. ***ROBERTS, ALEXANDER WILLIAM**, D.Sc., F.R.A.S., F.R.S.E. (Pres. A 1908; PRESIDENT, 1913), Lovedale, C.P.

1915. Roberts, Austin, P.O. Box 413, Pretoria.

1914. Roberts, John Lloyd, P.O. Box 529, Salisbury, Rhodesia.

1913. Roberts, Rev. Noel, The Vicarage, Orchards, Johannesburg.

1909. Robertson, Colin C., M.F., c/o Forest Department, Pretoria.

1906. Robertson, John, P.O. Box 138, Bloemfontein.

1915. Robinson, Eric Maxwell, M.R.C.V.S., P.O. Box 593, Pretoria.

1902. Rogers, Arthur William, M.A., Sc.D., F.G.S. (Pres. B 1910), South African Museum, Capetown.

1915. Romyn, Mrs. Elizabeth, Zonnehoek, 157, Troye Street, Pretoria.

1902. *Rose, James Wilmot Andreas, M.I.C.E., Patrys Vlei Farm, Stellenbosch, C.P.

1905. †Rose, John George, F.C.S., Government Chemical Laboratory, Capetown.

1913. Rosenthal, R., P.O. Box 1537, Johannesburg.

1912. ROSEVEARE, W. N., M.A., Professor of Mathematics, Natal University College, P.O. Box 375, Pietermaritzburg.

1914. Ross, John, P.O. Box 636, Kimberley.

1903. Rouliot, G., 37 bis, Rue de Villejust, Paris, France.

1902. *Runciman, William, M.L.A., Simonstown, C.P.

1915. Ruthven, Jane Buchanan Henderson, M.D., L.R.C.P., L.R.C.S., F.R.S.A., P.O. Box 6253, Johannesburg.

1903. Saner, C. B., A.I.M.E., P.O. Box 53, Krugersdorp, Transvaal.

1902. *Scaife, Thomas Earle, M.I.C.E., P.O. Box 23, Irrigation Department, Capetown.

1915. Schlupp, William Francis, B.Sc., Lecturer in Zoology and Entomology, Government School of Agriculture, P.O. Box 181, Potchefstroom, Transvaal.

1902. *Schönland, Selmar, M.A., Ph.D., F.L.S., C.M.Z.S., (Pres. C., 1908), Professor of Botany, Rhodes University College, Grahamstown, C.P.

1913. School of Agriculture, Cedara, Natal.

1913. School of Agriculture and Experimental Farm, Glen, O.F.S.

1913. School of Agriculture and Experimental Station, Grootfontein, Middelburg, C.P.

1913. School of Agriculture, Elsenburg, Mulder's Vlei, C.P.

1913. School of Agriculture and Experimental Farm, Potchefstroom, Transvaal.

Year of Election.

1916. Schreiber, Oscar Albert Egmont, P.O. Box 396, Pietermaritzburg.

1914. Schreiner, Hon. William Philip, M.A., M.L., South African Chambers, Capetown.

1903. Schumacher, R. W., c/o Central Mining and Investment Corporation, Ltd., 1, London Wall Buildings, London, E.C., England.

1902. SCHWARZ, ERNEST H. L., A.R.C.S., F.G.S., (Pres. B. and C., 1908), Professor of Geology, Rhodes University College, P.O. Box 116, Grahamstown, C.P.

1916. Scott, Rev. James, Claridge, Natal.

1914. Searle, Mrs. Amy M., B.A., Great Brak River, C.P.

1912. SERUYA, SALOMON, Vice-Consul for Portugual, P.O. Box 5633, Johannesburg.

1912. Shand, Samuel James, Ph.D., D.Sc., F.G.S., Professor of Geology, Victoria College, Stellenbosch, C.P.

1903. Shanks, Robert, 10, Graf Street, Johannesburg.

1915. Sherwood. Ernest Thomas Garton, M.A., Transvaal University College, Pretoria.

1902. *Shores, J. W., C.M.G., M.I.C.E., Rutland, Scottsville, Pietermaritzburg, Natal.

1916. Siedle, Otto, P.O. Box 931, Durban, Natal.

1916. Sim, Thomas Robertson, 168, Burger Street, Pietermaritzburg.

1914. Smail, William Mitchell, M.A., Professor of Latin, Rhodes University College, Grahamstown, C.P.

1902. *Smartt, Hon. Sir Thomas William, K.C.M.G., L.R.C.S.I., L.K.Q.C.P.I., M.L.A., Glen Bân, Stellenbosch, C.P.

1916. Smith, Hon. Charles G., Durban.

1915. SMITH, EDWARD HOLMES, B.Sc., School of Agriculture, Potchefstroom, Transvaal.

1906. Smith, Frank Braybrooke, Secretary for Agriculture, Union Buildings, Pretoria.

1915. Smith, Frank Cumming, Grootfontein School of Agriculture, Middelburg, C.P.

1912. Smith, George William, A.M.I.C.E., 11, Constitution Hill, Port Elizabeth, C.P.

1903. Smith, James, M.A., Normal College, Capetown.

1906. Smuts C., P.O. Box 1088, Johannesburg.

1905. Smuts, Hon. Jan. C., B.A., LL.D., Minister of Defence, P.O. Box 1081, Pretoria.

1914. †Smyth, Right Rev. Bishop William Edmund, M.A., M.B., c/o English Church House, 61, Burg Street, Capetown.

1916. Smythe, John Oswald, 123, Loop Street, Pietermaritzburg.

1903. Solly, Mrs. Julia F., Knor Hoek, Sir Lowry's Pass, Cape.

1903. Solomon, Hon. Justice Sir W. H., High Court of Appeal, Capetown.

Year of Election.

1908. Somerville, A. J., M.A., College House, Graaff-Reinet, C.P.

1910. †Soutter, John Lyall, P.O. Box 403, Pretoria.

1906. †Spencer, Dr. Henry Alexander, M.R.C.S., L.R.C.P., Middelburg, Transvaal.

1915. †Spensley, James Carter, M.A., Lecturer in Chemistry, Transvaal University College, Pretoria.

1905. Sperryn, Arthur James, J.P., P.O. Box 1, Ermelo, Transvaal.

1903. Spilhaus, William, c/o Messrs. W. Spilhaus & Co., Strand Street, Capetown.

1913. Stafford, Miss Susan, M.A., Huguenot College, Wellington, C.P.

1905. Stallard, C. F., K.C., P.O. Box 5156, Johannesburg.

1905. Stanley, George Hardy, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C. (Pres. B, 1914), Professor of Metallurgy and Assaying, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1905. Starkey, Samuel, Assistant General Manager's Office, System C, South African Railways, Johannesburg.

1904. Stead, Arthur, B.Sc., F.C.S., School of Agriculture, Grootfontein, Middelburg, C.P.

1912. Stead, William Godly Stockdale, P.O. Box 307, Port Elizabeth, C.P.

1908. Steedman, Miss E. C., M.A., Gando Farm, Gwelo, Southern Rhodesia.

1913. Stephen, Alexander, M.A., P.O. Box 518, Pretoria.

1903. Stevens, J. D., P.O. Box 1782, Johannesburg.

1909. Stewart, G. A., City Engineer, Bloemfontein.

1905. Stoneman, Miss Bertha, D.Sc., Huguenot College, Wellington, C.P.

1902. *Stott, Clement H., F.G.S., M.S.A., P.O. Box 7, Pietermaritzburg, Natal.

1916. Strapp, Walter Russell, M.D., 248, Loop Street, Pietermaritzburg.

1904. Struben, A. M. A., A.M.I.C.E., P.O. Box 317, Pretoria.

1906. Stuart, James, 34, Loop Street, Pietermaritzburg.

1906. Stucke, W. H., P.O. Box 2271, Johannesburg.

1915. Swierstra, Cornelis Jacobus, F.E.S., P.O. Box 413, Pretoria.

1915. Swynnerton, Charles Francis Massey, F.L.S., F.E.S., F.R.H.S., Gungunyana, Melsetter, Southern Rhodesia.

1904. Syfret, S. B., B.A., M.B., B.C., Main Road, Mowbray, C.P.

1905. †Tannahill, Thomas Findlay, M.D., C.M., D.P.H., Queenstown, C.P.

Year of Election.

1909. Teasdale, Miss Emma L., Government School, Maraisburg, Transvaal.

1913. Teixeira, Lieut. Augusto D'Almeida, Observatorio Campos Rodrigues, Lourenço Marques.

1906. Tennant, Sydney Dennison, P.O. Box 132, Ermelo, Transvaal.

1904. ***THEILER, Sir ARNOLD** K.C.M.G., D.Sc. (Vice-President; PRESIDENT, 1912), Director of Veterinary Research, P.O. Box 593, Pretoria.

1903. Thomas, Walwyn, B.C., M.B., B.A., 2, Greenham Villas, Annandale Street, Capetown.

1914. Thompson, Frederick Handel, B.A., Inspector of Schools, P.O. Box 4439, Johannesburg.

1902. *Thompson, William Wardlaw, F.Z.S., Kimberley Cottage, Kalk Bay, C.P.

1913. Thomson, Samuel, C.A., P.O. Box 228, Johannesburg.

1902. Thomson, William, M.A., B.Sc., LL.D., F.R.S.E., University Offices, Queen Victoria Street, Capetown.

1903. †Thorne, Sir William, Kt., Capetown.

1910. THORNTON, RUSSEL WILLIAM, Principal, Government School of Agriculture, Grootfontein, Middelburg, C.P.

1903. †Tietz, Heinrich C. J., M.A., Ph.D., Buona Vista, Burham Road, Observatory Road, C.P.

1916. Tomes, Rev. Alfred Edmund Godfrey, B.A., 181, Loop Street, Pietermaritzburg.

1908. Tooke, William Hammond (Pres. F, 1908), P.O. Box 30, Grahamstown, C.P.

1902. *Townsend, Stephen Frank, C.E., Rhodesia Railways, Ltd., P.O. Box 215, Bulawayo, Rhodesia.

1910. Trollip, W. L., Office of the Hon. the Administrator of the Cape Province, Capetown.

1906. Troup, James Macdonald, M.B., Ch.B., L.S.A., 230, Esselen Street, Sunnyside, Pretoria.

1916. Trubshaw, Henry Arthur, Seventh Avenue, Mayfair, Johannesburg.

1903. Tucker, William Kidger, C.M.G., P.O. Box 9, Johannesburg.

1906. Tyers, F. G., M.A., The College, P.O. Box 93, Potchefstroom, Transvaal.

1915. Van der Byl, Paul Andries, M.A., D.Sc., F.L.S., Natal Herbarium, Berea, Durban.

1912. Van der Lingen, Jan Stephanus, B.A., Erinville, Milton Road, Sea Point, Capetown.

1909. Van der Merwe, C. P., Experiment Station, Rosebank, C.P.

Year of Election.

1910\. Van der Riet, Berthault de St. Jean, M.A., Ph.D., (Pres. B, 1912), Professor of Chemistry, Victoria College, Stellenbosch, C.P.

1904\. Van der Sterr, W. C., P.O. Box 1066, Johannesburg.

1913\. Van Riel, Miss Johanna M., Huguenot College, Wellington, C.P.

1903\. VAUGHAN, J. A., P.O. Box 1132, Johannesburg.

1913\. Von Hafe, Joâo Henrique (Pres. A, 1913), Director of Railways, Lourenço Marques.

1915\. Von Mengershausen, Frederich Karl, B.Sc., Lecturer in Mining Engineering, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1903\. Von Oppell, Otto Karl Adolf, Department of Lands, Pretoria.

1912\. Wager, Horace Athelstan, A.R.C.S., Professor of Botany and Zoology, Transvaal University College, Pretoria.

1913\. Wahl, R. Owen, B.A., Grootfontein School of Agriculture, Middelburg, C.P.

1912\. Walker, James, M.R.C.V.S., P.O. Box 593, Pretoria.

1902\. *Waller, Arohm H., A.M.I.C.E., F.R.Met.Soc., Town Engineer, Bulawayo, Rhodesia.

1902\. *WALSH, ALBERT (GENERAL TREASURER, 1910-16), P.O. Box 39, Capetown.

1913\. Walsh, Lionel Henry, Brackley, Kenilworth, C.P.

1914\. Wark, Rev. David, M.A., The Manse, Woodley Street, Kimberley, C.P.

1907\. WARREN, ERNEST, D.Sc., Professor of Zoology, Natal University College, Pietermaritzburg, Natal.

1916\. Waterhouse, Osborn, M.A., Professor of English and Philosophy, Natal University College, Pietermaritzburg.

1906\. Watermeyer, Frederick Stephanus, P.O. Box 973, Pretoria.

1902\. *Watkins, Arnold Hirst, M.D., M.R.C.S., M.L.A., (Pres. D, 1906), Ingle Nook, Kimberley, C.P.

1906\. Watkins-Pitchford, Wilfred, M.D., F.R.C.S., D.P.H., South African Institute for Medical Research, P.O. Box 1038, Johannesburg.

1914\. Watson, Thomas Hunter, P.O., Box 1400, Capetown.

1915\. Watson, William Cruickshank, 13, Yeo Street, Yeoville, Johannesburg.

1906\. Watt, Dugald Campbell, M.D., 131, Pietermaritzburg St., Pietermaritzburg, Natal.

1912\. WAY, WILLIAM ARCHER, M.A. (Pres. D, 1912), Grey Institute, Port Elizabeth, C.P.

1914\. Webb, George Arthur, A.I.E.E., M.S.A., P.O. Box 3136, Johannesburg.

Year of Election.

1902. *Webb, H. H., M.I.M.M., 8, Old Jewry, London, E.C.

1916. †Webber, Walter Solomon, B.A., P.O. Box 1088, Johannesburg.

1911. Welch, Rev. Sidney Read, B.A., D.D., Ph.D., St. Mary's, Bouquet Street, Capetown.

1903. Wessels, Hon. Justice Sir J. W., B.A., LL.B., Pretoria.

1902. †White, Miss Francis Margaret, Trescoe, Cornwall Place, Wynberg, C.P.

1902. *White, Franklin, M.I.M.M., P.O. Box 617, Sydney, New South Wales.

1910. White, H. A., P.O. Box 41, Springs, Transvaal.

1902. †White, Miss Henrietta Mary, B.A., Trescoe, Cornwall Place, Wynberg, C.P.

1905. White, Maurice, M.A., Education Department, Volksrust, Transvaal

1902. *White-Cooper, William, M.A., F.R.I.B.A., P.O. Box 11, Cradock, C.P.

1915. Whitmore, Sidney W., Public Works Department, Pretoria.

1909. Whitworth, Walter S., Koffyfontein Diamond Mine, O.F.S.

1910. Wiener, Ludwig, F.R.G.S., Riebeek Street, P.O. Box 365, Capetown.

1904. Wilhelm, A. R. A., M.B., C.M., Barkly East, C.P.

1915. Wilkinson, David, A.R.S.M., P.O. Box 485, Johannesburg.

1915. Wilkinson, Frank, Lecturer in Dairying and Dairy Bacteriology, Grootfontein School of Agriculture, Middelburg, C.P.

1904. †WILKINSON, J. A., M.A., F.C.S., (Pres. B), Professor of Chemistry, South African School of Mines and Technology, P.O. Box 1176, Johannesburg.

1910. Wille, Friedrich Adolf, M.D., Ch.B., D.P.H., 11, Derby Road, Bertrams, Johannesburg.

1912. Willey, Edgar A., L.D.S., Potchefstroom, Transvaal.

1902. *Williams, Alpheus Fuller, B.Sc., Mining Engineer, De Beers Consolidated Mines, Ltd., P.O. Box 616, Kimberley, C.P.

1912. Williams, Cornelius, B.Sc., A.R.C.S., Government School of Agriculture, Cedara, Natal.

1902. Williams, Prof. D., B.Sc., Rhodes University College, Grahamstown, Cape.

1902. ***WILLIAMS, GARDNER F.,** M.A., LL.D. (PRESIDENT, 1906), 2201, R. Street, N.W. Washington, D.C., U.S.A.

1903. WILMAN, Miss M., McGregor Memorial Museum, Kimberley, C.P.

1903. †Wilson, Arthur Marius, M.D., B.S., L.R.C.P., M.R.C.S., Jesmond House, Hof Street, Capetown.

Year of Election.

1909. Wilson, Alfred William, P.O. Box 24, Langlaagte, Transvaal.

1909. Windram, James Thomas, P.O. Box 3547, Johannesburg.

1912. Winter, Rev. Johannes August, Onverwacht, P. O. Sekukuni, District Lydenburg, Transvaal.

1903. †Winterton, Albert Wyle, F.C.S., Lemoenfontein, near Beaufort West, C.P.

1906. Wood, H. E., M.Sc., F.R.Met.S. (General Secretary 1913-1916), Union Observatory, Johannesburg.

1905. †Wood, James, M.A., P.O. Box 2, Kingwilliamstown, C.P.

1916. Woods, Mrs. Sarah Ann, 211, Commercial Road, Pietermaritzburg.

1915. Wyatt, Stanley, M.Sc., Normal College, P.O. Box 855, Pretoria.

1904. Young, Professor Robert B., M.A., D.Sc., F.R.S.E., F.G.S., (Pres. B, 1913), P.O. Box 1176, Johannesburg.

INDEX.

22